ESSAYS ON FINANCING BUSINESS INNOVATIONS

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Declaration of originality

I, Leana Velko Ugrinovska, declare that this thesis and the work presented in it are my own work, except where specific reference is made to the work of others. This thesis has not been submitted for the award of any other degree or qualification at any other university.

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To my daughter Vasilia

To my mother Andrea and grandmother Pravda, who knew I was capable of this before I could even dream it. Without their unconditional love and support I would have never achieved this.

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Abstract

The motivation for this thesis stems from the importance of innovation activity for the economy. The study consists of three related essays which provide new theoretical insights and empirical evidence on the use of public financial instruments for financing business innovation. Specifically, the study provides analysis of the potential role of the financing instrument, revenue-contingent loans (RCLs), with respect to innovation policy for business, in comparison to the conventional system of grant support.

The first essay, 'The theory of revenue-contingent loans for business innovations', takes a theoretical approach to investigating the influence of different financing options (debt, equity and RCLs) on cash flow and on the efforts of innovators, and provides a simple theoretical model for the use of RCLs in this capacity.

The second essay, 'Estimating government subsidies with revenue-contingent loans for business innovations in Australia', provides calculations of government subsidies associated with the use of RCLs as an innovation financing mechanism, using a recent sample of Australian firms with different design parameters. Subsidy estimates are provided for different levels of debt and a range of parameters, including interest rates, repayment rates, loan surcharges and grace periods.

The third essay, 'An impact evaluation of direct public financial support for business innovation activities in Australia', estimates for the first time the effects of direct public financial support (grants) for innovative businesses in Australia. Using Australian Bureau of Statistics (ABS) firm-level micro-data, estimates are derived concerning the extent to which firms increase innovation in response to direct government financial incentives. The results suggest significant positive effects for innovation outputs and, to a lesser extent, for business performance indicators. However, important caveats are explained with respect to the limitations of the methods used.

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List of abbreviations

ABN	Australian Business Number
ABS	Australian Bureau of Statistics
ATO	Australian Tax Office
BAS	business activity statements
BCS	Business Characteristics Survey (ABS)
BLD	Business Longitudinal Database (ABS)
CQR	conditional quantile regression
DSB	Derived Size Benchmark
GDP	gross domestic product
GERD	gross domestic expenditure on R&D
HELP	Higher Education Loan Program (Australian Government)
OECD	Organisation for Economic Co-operation and Development
OLS	ordinary least square (regression model/analysis)
PAYG	pay as you go
R&D	research and development
RCL	revenue-contingent loan
RIF	recentred influence function
SMEs	small to medium enterprises
St.dev.	standard deviation
UQR	unconditional quantile regression
US	United States
VC	venture capital

Chapter 1 Introduction

The motivation for this thesis stems from the importance of innovation activity for the economy. The study consists of three related essays which provide new theoretical insights and empirical evidence on the use of public financial instruments for financing business innovation. Specifically, the study provides analysis of the potential role of the financing instrument, revenue-contingent loans (RCLs), with respect to innovation policy for business, in comparison to the conventional system of grant support.

This research has two aims.

The first aim is to provide new insights concerning the effectiveness of current public innovation policy for businesses. This matters because there is a growing awareness among economists and government officials about the critical role of innovation for economic growth (Bartel *et al*. 2007; Griffith *et al*. 2006; Hall *et al*. 2009; Halpern *et al*. 2012; Palangkaraya *et al*. 2015; Raymond *et al*. 2010). The issues are complicated because innovation, which is different from research and development (R&D), is an ever-changing phenomenon for which there is no single, fully satisfactory definition. The cross-sectoral nature of innovation incorporates a broad set of mechanisms, actors and instruments, not only in the field of R&D, but in education, technology, specialised services, and entrepreneurship, among many others. But which factor in innovation is the most important for understanding its role in economic growth?

Schumpeter (1934), in his theory of economic development, highlights innovation complexities with the notion that economic growth follows when the means of production are used in newer and more efficient combinations, and that the forces behind these 'creative destructions' are entrepreneurs. This idea was further supported by an early attempt at measuring the growth of outputs using just the growth of inputs (capital and labour), with a 'famous' 85% residual, implying, for example, that smart people can increase total output in an economy by increasing their firms' output with the same number of inputs (Abramowitz 1956) through technological innovation (Solow 1956). In interpreting this, history has demonstrated that innovation is not strictly due only to technical dimensions of technological progress, but that there has always been a human component in innovation in connecting technical opportunities with market needs.

Given their significance as engines of labour creation, innovation and economic activity, supporting new entrepreneurs and fostering the creation of new firms, especially innovative small and medium enterprises (SMEs), is a high priority for many countries (OECD 2005, 2012). For small firms, access to finance appears to be the highest barrier to innovation (Levin *et al*. 1987; Mansfield *et al*. 1981; Martin and Scott 2001; Hall and Lerner 2010). This highlights the potential value of research, such as that presented in this thesis, which focuses on financing innovative entrepreneurial firms, which (according to the OECD[1]) are SME's[2] (less than 200 employees) and innovative firms (firms that are introducing innovation that is new to the market or new to that firm only) and policy to assist with this.

Innovation is often associated with great uncertainty, long planning and implementation timeframes, and thus high costs, especially primary, science-based innovation that usually has

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[1] OECD (2013).
[2] ABS (2001).

as a product an intangible asset (knowledge). SMEs, which have limited internal funding and variable cash flow, cannot easily bear these costs. Knowledge does not constitute saleable and secure collateral to attract external investments, and as knowledge is much embedded in human capital, innovators cannot be sure that they would reap the rewards of such an effort, partly because these fruits lie so far in the future. As noted in Knight (1921), uncertainty is not a synonym for risk, and as innovations are uncertain investments as well as risky, it is difficult for investors to invest in innovation projects using standard methods of risk assessment.

Further, due to a variety of market failures, raising funding, especially for innovative SMEs, can be quite challenging through the private sector. Hence, there is a rationale for both public intervention and funding of these risky and uncertain investments. As argued in Stiglitz and Weiss (1981), firms experience financial constraints when they do not get necessary funds even though, in other aspects, they would fulfil all the intrinsic conditions for successful innovation.

The second aim of this thesis is to contribute new insights to this important policy area by exploring the potential role of a financial instrument which both lies beyond the private finance market and is different to the common public policy response of grants. This alternative (or perhaps supplementary) direct public financial instrument—revenue-contingent loans (RCLs)—is one in which firms are provided with financial resources in the form of a loan that is repaid, not on the basis of time, as is the case for all commercial debt, but instead when the firm has the capacity to repay, as measured by annual revenue. The objective is to examine the nature of this proposed new policy instrument for innovation and its potential effects on businesses and taxpayer subsidies. The comparisons for this are with existing debt and equity financing, and government grant assistance.

From a government's viewpoint, it is vital to minimise policy uncertainty and to design stable policy instruments. The choice of a public financial instrument for funding innovation relies on a combination of factors, of which cost has a great influence.

Currently, governments are perceived as being there to fund risky ventures, while the private sector harvests the fruits of innovation (Mazzucato 2013). In comparison with grant schemes that have no direct returns to a government's budget, RCLs can be used as a pool for further financing of business innovations because of the ultimate obligation on the business to return the loan. Thus, it can be argued that RCLs might be a more sustainable option than the pure loss to the budget inherent in the provision of innovation grants.

Further, there are issues of administration which are not canvassed in detail in the thesis. In this context and following Stiglitz's notion of 'transactional efficiencies' (Stiglitz 2014), transaction costs are likely to be relatively low for contingent loans because a government, through its agencies, has unique monopolistic power over business taxation. This is also the case with respect to student loans with, for example, administrative efficiency for the Higher Education Loan Program (HELP) being extremely high. Further, in this electronic era, repayments can be collected directly, lowering operating costs and leading directly to increased social welfare.

This thesis consists of three related essays, which are presented in Chapters 2 through 4. Each of the essays have their own set of analyses, different methodology, and literature review. The concluding chapter pulls the research together.

These essays provide new theoretical and empirical evidence on financing business innovation with private finance and with direct public financial instruments. For the latter, the thesis first examines the concept of RCLs followed by consideration of the effects of grant assistance. Concluding remarks, including policy recommendations and suggestions for future research, are discussed in Chapter 5. A brief guide to the contents of each essay is given below.

Chapters 2 and 3 consider the application of RCLs for financing business innovation and, as such, are approached as a public financial product. In Chapter 2, an RCL is explored as a policy instrument for financing business innovation. The context and motivation for government involvement in the provision of financing business innovations to underpin this are described. The essay is a theoretical analysis of the influence of different financing options on the cash flow and efforts of innovators, where the arguments for and against RCLs are presented. The essay makes an original contribution to the literature via theoretical comparisons between debt, equity and RCL financing on cash flow and innovators' efforts.

Chapter 3 examines issues of RCL design, with product features of the RCL scheme for financing business innovations being outlined with respect to the Australian environment and using firms' official micro-data. If an RCL was to be designed for Australia, it would be critical for government costings and subsidy calculations to be able to project likely scenarios of future firm revenues. To this end, several static alternative models for simulating firms' life-cycle revenues are developed. This allows the choice of apposite projections which can then be used for required calculations for a range of RCL design parameters and assumptions. This is the first research to report analysis of the fiscal implications of RCLs for government and provides a template that might be useful for the Australian government in reconsideration of the potential for financing innovation in the future.

While Chapters 2 and 3 are motivated by the potential benefits and costs of RCL for innovation, Chapter 4 explicitly examines the dominant present and historical innovation government policy in Australia which takes the form of grants. Using ABS micro-data on SMEs in Australia, the essay reports econometric analyses of the effect of grants on innovation output and business performance. This chapter makes an original contribution to the literature on the effects of public grant support for business innovations and, as far as can be gathered from the literature, it is the first study to have examined this issue for Australia.

It is apparent from the work of Chapter 4 that grants have been associated with higher levels of innovative activities and, to a lesser extent, business performance (as reflected in labour productivity and sales). However, it is well known in studies of these types that there are potentially major technical challenges related, specifically in this case, to the endogeneity of innovative activity which can be traced in part to the problem of omitted variables. The dataset lacks important information on observed factors, such as R&D expenditure, revenues and profits, as explained in detail in Chapter 4. Further, many unobserved factors could influence innovation activity, such as motivation, network capabilities, and soft management skills.

In the concluding chapter, Chapter 5, the case is made that, to the extent that grants do have a positive benefit for innovation, these outcomes would presumably be forthcoming if innovation financing policy instead took the form of an RCL. Such a reform has the potential of benefitting many more firms and many additional projects because significant proportions of the outlays would be recovered and become available for expanded coverage of innovation policy. Of course, such an assessment depends critically on the efficacy of the RCL conceptual discussion covered in this thesis.

Chapter 2 Theory of revenue-contingent loans

2.1 Introduction

This chapter presents a simple model of revenue-contingent loans (RCLs) as a potential, substantial policy pathway for government financing of business innovation. RCLs are a type of loan in which repayments depend on the revenue of the borrower. From a small firm's viewpoint, the advantage of a contingent loan compared to a standard loan is that fixed repayment obligations with respect to time are avoided. No fixed payments entail default protection for the firm. If a firm does not generate revenues in a particular period, there is no repayment. There is also revenue smoothing, as firms repay their debts only when they are able to afford to, eliminating the risk of bankruptcy attributable to having difficult loan repayment obligations.

This essay's main goal and research question is to theoretically illustrate, under plausible conditions, how different financing options might affect firms' cash flow and innovators' efforts using capital structure theory (Modigliani and Miller 1958), contract theory (Laffont and Martimort 2002; Bolton and Dewatripont 2005) and neoclassical microeconomic theory for profit functions and maximising values for quantity, price and profit. The model assumptions are that firms are risk-neutral, and hence maximise their profit when marginal revenues equal marginal costs and the expected profit from innovations for a firm should be non-negative and have linear demand and cost function.

This essay provides an economic theory in an area where there is little economic theory, providing significant benefits for further theoretical developments. This essay shows how RCLs are different from traditional ways of financing firms (debt and equity) and why, with and without asymmetric information, RCLs might be the preferred choice of finance for some innovative entrepreneurial firms. Governments might have an advantage for supporting this instrument where the private market for RCLs is incomplete.

It should be emphasised that this essay is not a completely comprehensive theoretical discussion of the RCL topic from a government perspective. In particular, social welfare maximisation is not discussed in detail. Further, this essay is not a complete theoretical model with all realistic assumptions, such as asymmetric information, loss of ownership and risk of bankruptcy, included. The author's goal is instead to illustrate how different financing options (RCLs, debt and equity financing) might affect an innovative firm's cash flow, and innovator's efforts with a starting-point simpler model. The author's hope is that in doing so, a better sense of the benefits and limitations of each of the theoretical models can be provided as a base for further research, both as to theory but also, more immediately, as to empirical and policy analysis.

The rest of this essay proceeds as follows. Section 2 discusses innovation. It begins by defining innovations and discussing why innovations are hard to finance and why government should be involved in financing business innovations. The possibility of the use of RCLs is described in this context in Section 3, recognising Australia's distinctive role in advancing this loan type as a useful finance instrument. Section 4 presents the theoretical model for such RCLs so that their core nature can be formally and clearly defined. This then allows Section 5 to theoretically compare three financing options (debt, equity and RCLs financing), and to clearly examine their potential effect on a firm's cash flow and an innovator's effort. Section 6 concludes what is learned about RCL from its theorization relative to private finance and how that supports the value of further examination of its potential.

2.2 Review of prior literature

2.2.1 Why the market for innovation finance fails?

For the purposes of this essay, the following OECD definition of innovation is used:

> Innovation is the implementation/ commercialization of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer ... the implementation/adoption of new or significantly improved production or delivery methods... involv[ing] changes in equipment, human resources, working methods or a combination of these. (OECD 2005)

Everything starts from ideas that are then materialised. The focus of these essays and thesis is on innovations rather than on inventions.[3] Many authors have found that innovations affect productivity positively (Bartel *et al*. 2007; Griffith *et al*. 2006; Hall *et al*. 2009; Halpern *et al*. 2012; Palangkaraya *et al*. 2015; Raymond *et al*. 2010). According to a review of the economic literature regarding innovations (Palangkaraya *et al*. 2016), innovations are regarded as investments for enhancing productivity and the expected benefit is greater than zero.

There is a growing literature that has continued to document, especially in the early stages of innovation, that innovation activity is more difficult to finance than other types of investments (Hall and Lerner 2010; Levin *et al*. 1987; Mansfield *et al*. 1981; Martin and Scott

[3] The invention is a novel idea, while innovation is transforming that idea into reality.

2001). Financial constraints for innovation usually arise because of factors such as the existence of market failures, incompleteness of markets, uncertainty, firm size, demographic characteristics, etc. A starting proposition for different approaches is to understand how these above-mentioned factors impact the way that innovation can be commercialized and why the source of capital matter for the type and outcome of innovation activity (Kerr and Nanda 2015). Generally, markets invest less in innovation than is socially optimal, as the social return to investment in innovation is higher than the private return. That is the rationale for why many governments intervene, designing different policies to reach the "optimal" level of innovations. The four fundamental reasons preventing investments in innovations are: non-rivalry of innovation, non-excludability of innovation, incomplete information and uncertainty. Non-rivalry and non-excludability as market failures come from the public-good attributes of innovation, which generate spillover effects or externalities beyond the appropriable and/or rival private-good dimensions. Non-rival means that a certain innovation by an innovator does not preclude other innovators from using it, whereas non-excludability is partial for most innovations as the innovator is often unable completely to prevent others from using the innovation without authorization. The innovator of, or the investor in, the innovations usually cannot capture all the benefits from the innovation itself after the first-mover profits, as other actors in the market can replicate their innovation, fully or partially, and learn from it (even failures provide valuable lessons) The innovators can try to protect themselves with intellectual property rights[4], secrecy of first-mover advantage, but in this era of information technology and the free movement of human capital between firms, this

[4] Non-rivalry and non-excludability of innovations are the main reasons why innovations need protection through patents etc.

protection is often insufficient. This significantly lowers private returns for innovators, giving them and the market less incentive to invest in innovations.

A third market failure lies in the incomplete information and information asymmetry between innovators and potential investors, as especially emphasised in the early stages of innovations when they are at the stage of ideas and knowledge. Innovators have more information than potential investors[5], both about the real incentives for developing the project, which might differ from an investor's goal of maximising profit, as well as the true risk of the project. Therefore, the market for innovation investments resembles the "lemons" market modeled by Akerlof (1970). Adverse selection arises from that fact the innovator might have more information regarding the project than the financier. (Dechenaux *et al*. 2009; Jensen and Thursby 2001; Macho-Stadler *et al.* 1996). The market does not know the true risk, it assumes higher default risk and sets higher interest rates, and as investors have more issues distinguishing good from bad projects, they will attract only high-risk projects as their innovators are willing to pay the higher rate. The higher rate discourages innovators with lower-risk projects from applying for funding, leading to a further increase in interest rates. In the most extreme version of the "lemons" model, the market for financing innovation might completely vanish. Venture capital could be viewed as a solution to the 'missing markets', as the market can often be flexible enough to mitigate its own failures[6]. Certainly, one might expect through certain rules of fuller disclosure and signaling (such as patents), the "lemons" problem to be mitigated, but not fully eliminated due to the ease of innovations' replication. Further the quality of signals firms make about their innovation projects might be

[5] Although sometimes investors have more information regarding the market than the innovators, who might lack knowledge on administrative processes etc.
[6] Examples from the past regarding market mitigating its own failures: marine insurance and shipping in the 15th C; joint stock companies and the financing of railways 19th C.

reduced since innovators are unwilling to reveal their innovative ideas to the market. (Anton and Yao,1998; Bhattacharya and Ritter, 1983).

Moral hazard in innovation investments arises in two ways due to the principal-agent problem. First, an issue might arise between the investors and innovators, as once innovators receive the investment, they might take more risky projects than previously agreed with the investors because in case of failure the loss is capped, but in case of success they get all the benefits. Second, issues arise especially in equity financing due to the separation of ownership and management. The direction of the problem will depend predominantly on the innovators' willingness to undertake risks. If the innovators are risk takers, they might be willing to undertake projects which benefit them, but do not maximize the shareholders' value, and shareholders might not be able to observe easily if their behaviour deviates from the behavior that would have maximized the firm's value. The shareholders might leverage the firm in order to avoid the agency costs but this might turn innovators to seek external sources for funding their innovations which lead to higher costs (Jensen and Meckling, 1976). On the other hand, if the innovators are more risk-averse they might be reluctant to invest in certain riskier innovation projects, and long-term investments with variance-increasing projects might suffer. In this case, shareholders instead of reducing the free cash flow to the innovators might increase the long-term incentives for the innovators.

The outcome of incomplete information problem is that the innovation projects with positive net value might not be financed, hence not be developed as they might fail to attract enough external funds.

In order to reduce the information asymmetry problem, investors might ask for a collateral they can seize in case of default and/or co-funding and personal guarantees. However, funding innovations with debt is quite burdensome and difficult for firms as debt requires tangible collateral, and knowledge in innovation is intangible collateral (de Rassenfosse 2012; Hall 2005; Himmelberg *et al.* 1994; Canepa *et al.* 2008; Carreira *et al.* 2010; Czarnitzki *et al.* 2010; OECD 2015; Schumpeter 1934). Knowledge is embedded and inseparable from a firm's personnel, so when they leave a firm that knowledge is lost (Hall and Lerner 2010).

In particular, smaller and younger innovative firms do not have enough internal funding, nor tangible collateral and financial history, to obtain bank loans. Those firms are more likely to identify access to finance as the biggest hurdle for innovative activities and rely primarily on the business owner's financial resources (e.g. credit cards, savings, personal loans).

Uncertainty regarding innovation is another factor in financial constraint for innovation. As with any other type of investments, innovations are undertaken on a cost–benefit analysis, but greater uncertainty makes this calculation unreliable and it is usually missing from standard models (Coad *et al.* 2010; Thompson 1999). The expected value of ideas is highly uncertain, cannot be easily calculated nor, therefore, predicted accurately (Bullen *et al*. 2006; York & Venkatraman 2010) with consequences for issues of risk incidence (Arrow and Lind 1970).

Innovative entrepreneurs face many types of uncertainty, but they can be grouped into three categories: technological uncertainty (they can't be sure that the idea would be feasible and successful beforehand); strategic uncertainty (in this era of fast-spreading novelties, firms cannot be sure that they would be the first ones to introduce the innovation); and market uncertainty (even if the innovation is successfully turned from an idea into a product, the firms can't be certain that they would have buyers for it).

However, the distribution of profits from innovation is skewed (Scherer *et al*. 2000) making it hard for financiers to reduce the risk of investments through diversification. Hence, a further rationale for stable and certain innovation policy emerges in the literature (Marcus 1981) to help with assessment of the risk and uncertainty.

Findings from the case for Australian firms reveal that only 20–25% of innovative entrepreneurs seek external funding (ABS 2011). Smaller and younger firms are more innovative, according to some authors, who have found that the older and the larger the firm, the less innovative activities it exhibits (Abdelmoula *et al.* 2010; Acs *et al.* 1987; Becheikh *et al.* 2006). Innovative entrepreneurs have been recognised as crucial for sustainable economic growth, responsible for moving the economy from static equilibrium. As Schumpeter (1934, p. 132) stated:

‘Whatever the type, everyone is an entrepreneur only when he actually carries out new combinations and loses that character as soon as he has built up his business, when he settles down to running it as other people run their business.’

2.2.2 Alternative forms of government intervention to support innovation activity and their effects-what do we know?

On the other side, countries do need innovations, as knowledge is embedded not only in successful innovations, but also in the lessons of the failures of innovations. Those lessons diffused make a further case for much higher social returns than private returns in the innovation field. And as private returns are smaller than social returns, in order to have the social optimum of innovation, a presumptive case arises for the state to ‘interfere’ with investments (Arrow 1962).

Financial constraints for innovative firms do not exist strictly only because of market failures. As Hall (2002) notices, constraints can arise in some circumstances even if the returns for the innovator do not match those required by the financier.

Financial market failures are not the only rationale for government involvement. The broader literature on innovation also highlights the importance of other constraints, including the role of managerial capabilities (Hughes 2014). A wider conception of institutional and coordination failures between actors and institutions of the innovation system are in reality another cause of underinvestment and a driver of government interferences. Government has the unique power of setting up institutional frameworks and underlying infrastructure, and ensuring that all parts of the innovation system are functioning. Pure market theory takes suitable institutions for the operation of markets as given. Government, in particular, fills in the information gap of innovators by providing training which has its own market failure issues, for instance, as innovators may lack business and financial skills, which are necessary to successfully present their projects and attract investors from the market.

Sometimes governments intervene, not to build a system or to solve a problem, but rather to set a socially desirable goal beyond that encompassed by profit motivation and to invest in those innovative businesses that would tackle that goal, for example clean technology or sustainable energy. Palangkaraya and Webster (2015) showed in their review the positive effect of government support programs on the innovative activities of relevant firms for new-to-the-firm innovations.

Government can finance innovations through direct finance instruments and indirect finance instruments. The vast literature on government programs for innovations is largely about the impact evaluation of indirect financial instruments, specifically R&D tax concessions, and finds positive correlations for those programs on new-to-the-world innovation (Wu *et al*. 2007). However, according to De Rassenfosse, Jensen and Webster in *Understanding Innovation* (n.d.), direct government funding would produce more spillovers than tax incentives.

2.3 The nature of revenue-contingent loans- what do we know? And, what do we know about their application to financing innovation?

In 1989, the Australian Government pioneered a public financial instrument to finance higher education: Income Contingent Loans (ICLs).[7] Since then, the concept has been accepted and established as a policy by many other countries. However, so far, although empirically and conceptually successful, there is still an obvious need for a clearer theoretical framework that would help embed the more general use of public contingent loans. There have been many studies suggesting other policy areas where ICLs could be implemented. One of those studies proposes ICLs for financing business innovations (Gupta and Withers 2014, pp. 156–164).

This chapter aims to fulfil the abovementioned gap by developing a theoretical framework for analysing RCLs for business innovations. Revenue-based financing and/or royalty-based financing are not a new phenomenon. These financial instruments have been used since the early 1900s by gas and oil drilling companies, and later used by energy, the pharmaceutical and movie industries, to finance their high upfront costs. Since the 1980s, investors have generated interest for such loans for investments in early-stage firms, particularly high-tech firms, because of their high margins and high growth potential.

[7] ICL is a public financial instrument where repayment of a loan to be paid by the borrower depends on his or her income. In this thesis, income is defined as the gross income (sum of all wages, salaries etc) for individuals and households, not for firms. For firms, revenues and profits are being used. Revenues are defined as total earnings generated from firm's main business activities, sales of goods and/or services, or any other use of capital or assets, without costs or expenses being deducted. Profit is the amount of earnings that exceeds expenses, and it is calculated as difference between revenues and costs.

Revenue-based financing has been justified by many studies so far primarily because of the two main market failures: asymmetrical information (Beggs 1992; Gallini and Wright 1990; Macho-Stadler and Perez-Castrillo 1991; Poddar and Sinha 2002) and moral hazard (Choi 2001; Macho-Stadler *et al.* 1991).

Analogous to income contingent loans, RCLs are types of loans in which repayments depend on a firm's future revenue. The government acts as an investor, injecting initial capital into small and medium enterprises (SMEs). Once they start having gross revenues above a certain threshold, and only in the years they have them, the firms repay the part of the initial loan at a specified percentage of their revenue.

The author, although initially considering profit contingent loans as well, decided to continue with RCLs only, due to the potential moral hazard problem that might arise between the investor and the innovator firm when the loan might be repaid from the profit. The accounting can be very complex. Also, when payments are from more transparent revenues, firms can focus on more efficient ways of decreasing costs.

This financing option sits between two traditional private market options: debt financing and equity financing. Debt financing, typically a bank loan, requires a collateral or other personal guarantee, and repayments are fixed, regardless of a firm's revenues, and must be repaid by certain fixed date. That puts a huge burden on a borrower in periods when business is not running smoothly with nil or negative revenues. It might lead a firm into potential bankruptcy, where the firm might not only lose the entire business, but any collateral as well.

However, some studies have shown that revenue-based financing is inferior to fixed-fee financing (Kamien and Tauman 1984, 1986; Kamien *et al*. 1992), while others have shown that revenue-based financing is superior to fixed-fee financing (Sen 2005). Additional problems with standard bank loans are that SMEs, and particularly starts-ups, do not have well-established financial histories, and innovation cannot be considered as sound collateral. The only option left for innovators is to guarantee risky business undertakings with their personal assets, producing even further hardships for securing traditional loans.

Equity financing (venture capital or business angel investments) does not necessarily need to be repaid by a certain date, but may require loss of control over the firm. An investor requires from a firm borrower an ownership portion, and usually venture capitalists are interested in high-tech and fast-growth firms with well-established business plans. Apart from providing funds for innovators, venture capitalists provide an array of management and business expertise that the innovator does not possess or may not be in a position to procure through consulting or internalization given their scale of operation. Hence, equity financing provides more value than mere financing (Lerner and Nanda 2020).

Further, venture capital (VC) markets are not equally developed across the world. They are the most developed in the US (Kortum and Lerner 1998) claim that it is 3% of total R&D spending). Existence of VC markets is crucial for innovations: the strong Israeli rise of innovation is attributed to connections with the US VC market (Breznitz 2007). Some authors have even emphasised the need for government support for VCs because of the risks of market failures (Dodgson *et al*. 2011), while others have found that public investments in VCs are positively affecting investments periods (Buzzacchi *et al*. 2013).

The literature on traditional financial instruments so far has noted that preferred financing might depend on innovators' preferences towards the risk and innovators' abilities. Risk-averse or lower-skilled innovators would be more willing to give an ownership portion to venture capitalists to share the risk (Amit *et al*. 1990). Other studies have shown that risk-averse innovators would prefer revenue-based financing (Bousquet *et al*. 1998), and better innovators prefer revenue-based financing over fixed-fee financing (Gallini and Wright 1990). Other authors have argued that loss of ownership is not desirable, and internal funding is the best option (Lazonick and Prencipe 2005).

So, with only two standard private financial options available, business owners are often left with no alternative but to finance their innovative start-ups from their own personal assets. Thus RCLs may represent a better alternative financial source for them, where firms can have performance-linked, flexible payments without giving up a portion of their ownership. With RCLs, a firm would only need to give up a share of the firm's future revenues until the debt is repaid.

From a firm's perspective, RCLs might be superior to the traditional loan as RCLs have built-in insurance against default on non-repayment of the debt (Chapman 2014). Unlike traditional bank loans where a loan is repaid in fixed instalments over the lifetime of the loan regardless of whether a firm is experiencing hardship, RCLs are only paid when firms are earning revenues above a certain threshold.

RCLs are very important for risk and uncertainty reduction. In the case of exogenous shock (market demand or technological), smaller profit would be offset with no repayments for an RCL. This is a huge advantage in comparison to debt repayments or equity financing, especially with the dividend smoothing policy, where the financial risk is higher than with the residual payout dividend policies (Aivazian *et al*. 2006). RCLs are different from non-voting stocks because RCLs would be repaid from revenue, while non-voting stocks would get dividends from the profit that is not retained for the current financial year.

2.3.1 Government as a risk manager

The need for government intervention in access to finance for innovative entrepreneurs has been well established (Howell 2015; Lerner 1999). Public investment builds the nation's capital stock by devoting resources to innovative activity that leads to higher productivity. However, whether innovation shall be supported is a subset of the optimal rate of investment question, debate started back in 1950s and 1960s (Aschauer 1989). If the government wants to raise the innovation rate, RCL and other financing option can be considered.

Governments should not only reform financial systems, but be a part of them as well because the design of financial systems affects the level of success of innovation (King *et al*. 1993).

At present, governments across the world usually finance innovative businesses with grants. Innovative businesses are quite risky, with few chances for success, but successful innovative businesses can become significant factors in the overall economy and economic growth of a country. Hence, governments could choose better options than using taxpayers' money to finance innovation through grants, which is not the best option from a cost–benefit analysis point, as discussed more in Essay 2 (Chapter 3). As Nicholas Barr wrote, 'Any fool can give away the money. The difficult part is getting it back' (Barr 2014, pp. 63–75).

A more suitable way for governments to recover funding provided through their interventions might be RCLs. Up until the present, government has been regarded by some economists as the ultimate risk manager (Moss 2004). Some other economists, as described by Nicholas Barr in his 2001 book *The Welfare State as Piggy Bank*, regard the state as necessary in areas of insurance where the private sector is inefficient. Alongside the state's roles of risk manager, piggy bank and Robin Hood for the poor, a state should be an entrepreneur as well (Mazzucato 2013). For sustainable long-term growth, governments might adopt a business mindset and undertake those policies that would have a small cost/benefit ratio and could generate revenues.

Public RCLs have at least two advantages over RCLs that can potentially exist on the private market: ‘transactional efficiencies’ and precedent claimant.

RCLs have low administrative, transactional and debt-collection costs because government agencies in charge of collecting taxes have both the legal power of knowing a firm’s revenues and the power to make withdrawals when those withdrawals are due. The existing tax architecture with fixed costs could be used for collecting RCLs, lowering marginal transactional costs through ‘economies of scope’. Related research regarding the experience with present ICLs in Australia shows that the operational costs for ICL are less than 5% of the annual revenue (Chapman 2006).

Denniss (2014, pp. 248–259), building upon the Stiglitz notion of transactional efficiencies, argues that the position of a government in having low transactional costs is further enhanced with technological developments, where almost all of the transactions can be done online, directly increasing social welfare.

Social welfare would be further increased with risk pooling instead of risk sharing, meaning that those who are successful would pay a part, instead of taxpayers bearing all the costs of unsuccessful business projects. Innovations are quite risky, but rewards are enormous. This is the idea developed by Le Grand (1991) that the lucky ones should pay for the unlucky. On top of the cost of borrowing and administrative costs, innovators would pay plus cohort risk premium (Higgins 2014, p. 133; Barr 2014, pp. 63–75).

Second, government has the power to collect debts together with taxes directly from revenues, hence being the precedent claimant, while of RCLs, private investors are residual claimants, who bear the residual risk, making the private investors less willing to invest in long-term innovative projects with high uncertainty.

As it is difficult to deal with uncertainty, the consequences are incomplete private markets for RCLs. In complete markets, all allocations are Pareto optimal and comonotonic[8] (Chateauneuf *et al*. 2000). However, with innovation projects, each project would not only be risky, which could be substantially mitigated with diversification, but uncertain as well. Especially new-to-the-world innovations carry high new-technology uncertainty and/or project uncertainty, as well as systematic uncertainty (i.e. would it be materialised on the market and if the market would exist at all, as with many innovations, the innovation precedes the existence of the market).

Along these lines, asymmetry uncertainty is highly possible with innovations, as transacting parties might have different information regarding the project (Morris 1997). There are no objective probability functions for uncertainty[9]; hence, allocations are not comonotonic and complete markets do not exist for RCLs for business innovations.

As uncertainty is much higher than the systematic economic average, there would be no other options for free private markets to provide RCLs for business innovations. Following Mukerji

[8] There is perfect positive dependence between components of a random vector, or components of random vector can be represented as increasing function of a single random variable.
[9] Confidence in estimating the marginal benefit, marginal cost and rate of return for uncertain investments is poor. Hence, the estimated business plan may be too unstable and volatile for people to act upon.

and Tallon (2001), conditions for an incomplete market to exist for some financial assets (in this case the financial instrument RCLs) are fulfilled.

Further, as uncertainty cannot be reduced, rather just transferred, private markets would not have an incentive in taking risks to finance huge highly uncertain projects for which a proper risk assessment cannot be done (there is no counterfactual to be used for compression traded on the market). However, the cost of uncertainty can be spread through taxpayers (Arrow and Lind 1970), or through successful applicants and that is the advantage of government.

Nevertheless, government has its own failures, so before deciding upon an intervention, all costs and benefits should be weighed.

Positive theories of government state that public choice focuses on politicians' interests. Their interests usually correspond with their main short-term goal to be re-elected, pushing politicians into inefficient decisions which are further pronounced by special interests of the rent-seeking groups whose money and votes politicians need to stay in power.

Another limitation of government is bureaucrats, who usually do not have the necessary expertise as private markets have, for example in due diligence processes. Hence, governments do still use financial markets as direct intermediaries in the implementation of access to finance schemes for innovations.

This problem is deepened with additional information asymmetry by the financial markets which are losing their incentive for a comprehensive due diligence process, as with public RCLs, government bears all risks and losses.

2.4 The basic model of revenue-contingent loan

In this section a relationship between a government or a certain government agency (the financier) and a firm applicant (an innovator) is modelled. In this model existence of perfect capital markets is assumed, where a firm has different funding options. The financier (government) decides to offer a contract to an innovator after a due diligence process. If the innovator accepts, the innovator undertakes an effort *Eit* to commercialize the idea and to bring the product to market.

The assumption is that the effort is strongly related to the capabilities of an innovator. Different innovators would have different levels of capabilities (high capabilities c_h and low capabilities c_l) thus efforts. For the financier, it is cheaper to finance more capable innovators than less capable innovators.

However, highly capable firms may claim to be low-capable and reduce their efforts, and the financier cannot effectively monitor innovator's effort; hence, the moral hazard problem might arise. An innovator might know their true capability, but might not reveal it to the financier, and asymmetric information is present.

One of the options to 'force' or to motivate the innovator to reveal their true type and their future efforts, is for the financier to give multiple contracts from which the innovator can choose, as suggested by Beggs (1992).

It is assumed that the probability of the idea becoming a commercial success is $p \in [0,1]$ and it is positively related to the effort *p(e).* If the idea commercialises, there would be positive private returns *PR>0* and social returns (*SR>0*);[10] if the idea fails, both returns would be 0.

A further assumption is that the government is risk-neutral and thus finances projects based on their social return signals.

With RCLs, the financier would provide a lump sum of money to the innovator for developing and commercialising an invention, which would be repaid by future revenues according to an agreed schedule. Repayments would not be made until revenues reach a certain threshold x. At time of the loan t=0, the assumption is that revenues are zero. The total capital (K) necessary for undertaking the innovative project is known and can be financed through different sources.

With RCLs, capital might be provided as a matching fund between the financier and the innovator. In this case, it means that the innovator should raise a certain amount *m*, and the rest *1-m* would be provided by the financier as a loan *L=1-m*. Let *L* be the loan repayment of the firm's revenue R. The simplest RCL would be *L=αR,* where:

$L=0$ *for* $R<Rt$

$L= \alpha R(x)$ *for* $R>Rt$

If revenues are below a certain threshold (*Rt*), there would be no repayment obligations, and when above the threshold a certain share of revenues for the RCL would be repaid.

[10] Positive externalities, the reason why government finance innovations.

The financier, after obtaining a signal about the social return of the innovative project, offers a few different contracts to the innovator. However, the government (the financier) would lend *L* dollars to a certain number of innovators *I*, with a total amount of *LI* at a certain interest rate $r>0$.

As innovations are quite risky, many of them would be unsuccessful and firms would go bankrupt. The rest, the successful ones, should pay a higher interest rate (cohort premium risk) $r^*>r$, thus their repayments would be $(1+r^*) L$. The higher interest rate should be made also for maximisation of social welfare and avoidance of the crowding out of government payments.

A low and/or a lesser interest rate than the one offered by private capital markets would attract innovators who would be otherwise be financed on the private market; hence, no additional innovations would be made and there would be less budget for financing other projects. Still, the interest rate should not be a financial burden to the innovator and should be enough to repay the loan from its private returns $r^* \leq \frac{PR}{L} - 1$.

The model's boundary conditions (Lamoreaux and Sokoloff, 2007) are for any type of innovation, regardless if it is 'new to the world' or 'new to the firm' in their initial stages till commercialization, undertaken by innovative entrepreneurs[11] start-ups.

[11] It can be small or medium enterprise.

2.5 Debt, equity and revenue-contingent loan financing

With RCL now defined, in the next subsections traditional financing options (debt and equity) and this newly proposed RCL financing are theoretically compared using capital structure theory (Modigliani and Miller 1958), contract theory (Laffont and Martimort 2002; Bolton and Dewatripont 2005) and neoclassical microeconomic theory for profit functions and maximising values for quantity, price and profit. This helps make clear the characteristics of private finance and the new RCL proposal. The starting assumptions are that firms are risk-neutral, and hence maximize their profit when marginal revenues equal marginal costs and the expected profit from innovations for a firm should be non-negative.

2.5.1 Debt financing

With debt financing, the innovator repays the standard loan each month regardless of revenues and profit earned, until the innovator repays the total loan. There is a higher risk of bankruptcy as the innovator must repay the amount of loan D, not only in successful outcomes, but in failures as well. Payment obligations do not vary and that is the main difference with RCL, where the payments depend on the revenues and accordingly vary from one period to another.

From the innovator's perspective, the loss from failure would be high, as the innovator would need to repay the loan in any case (usually collateral is involved as well), but in case of success the gains are high, as they only need to repay the loan with a certain interest rate and no further payments after the repayment are needed to the financier.

From the financier's perspective the loss from failure is low if a collateral for the debt is provided, but the gains from successful cases are low as they get only the repayments with standard interest rate.

The expected profit from the innovation for the firm should be non-negative, otherwise the firm would have no incentive in taking the equity arrangement, and the debt financier would not have the incentive to invest. If the innovation is successful, the firm would choose the output to maximize the profit function:

$$p(e)[R(x) - C(x) - \mathrm{D}]^{12} \geq 0 \quad (1)$$

R(x) are the revenues of the firm, *C(x)* is the total cost, and D is the repayment amount for the loan that would be repaid under the agreed terms. The following equation is used for easier understanding, although in accounting the cost would include the debt amount as well:

$$\Pi(x) = R(x) - C(x) - D \quad (2)$$

Hence, the expected profit would depend only on the effort of the firm:

$$E_{\pi}(e) = p(e)[R(x)-C(x)-D]$$

$$= p(e)[PX-C(x)-D]$$

$$= p(e)\,[(a-bx+\mu)x - (f+c+\varepsilon)x-D] \quad (3)$$

[12] For simplicity, the profit function for the firm is $\Pi(x) = [R(x) - C(x) - D]$, where *R(x)=Px*, and inverse demand curve P=a-bx+μ, where μ is the uncertainty (exogenous shocks) on the demand side, and *C(x)=f+cx+ε*, for the purposes of this essay *C(x)=(f+c+ε)x*, where ε is the uncertainty (exogenous shocks) on the cost curve.

In the case where the innovator is risk neutral[13], the firm would maximize the expected value when the first order condition satisfies this condition:

$$R'(x)=C'(x)-D \tag{4}$$

$$(a+\mu)-2bx = (f+c+\varepsilon) \tag{5}$$

This indicates the maximizing values for quantity, price and profit:

$$x^*= \frac{(a+\mu)-f-c-\varepsilon}{2b} \tag{6}$$

$$p^*=\frac{(a+\mu)+f+c+\varepsilon}{2} \tag{7}$$

$$\Pi = P^*X^*-CX^*= b(X^*)^2 \tag{8}$$

which confirms that the profit of the firm with debt financing does not depend on the debt at all (see (8)); hence, the debt financing does not affect the cash flow of the firm, confirming results from Modigliani *et al*. (1958) that the finance structure does not affect the firm's value.

The expected utility from revenues and disutility from efforts do not depend on the debt, hence having no effect on it:

$$E_U (E, R, D) = p(E)\, U(R\text{-}D) +(1- p(E))\, U(0\text{-}D) - V(E) \tag{9}$$

$$E'_U (E, R, D) = p'(E)\, (U(R\text{-}D)\text{-}U(D)) - V'(E)= 0 \tag{10}$$

[13] An alternative approach to defining risk neutral instead as MB=MC can be 50% chance of $10 = 100% chance of $5.

Debt financing does not distort the innovator's efforts, or their decisions regarding the production process, but can lead to bankruptcy in the case of failure of the innovative project, because of the debt *D* they need to repay in total and the disutility from their efforts.

Because innovations are risky and uncertain, it is assumed that the demand and cost functions of the innovative firm are linear, and that they are incorporating the uncertainty terms, under the assumption they are normally distributed and independent of each other.

2.5.2 Equity financing

With equity financing, instead of paying a share of its revenues after a successful commercialisation, a firm gives equity to the financier. Now, equity share β is used, representing a percentage of a firm's future profits from innovation, where $\beta \in [0,1]$. The innovator's optimal level of effort is $e^*(\beta)$. Usually, equity financing means taking a fraction of the ownership and loss of control over the firm; however, for simplicity of this model it is assumed that there is no loss of ownership. From the innovator's perspective, in the case of success, the gain would be less because of the equity, but in case of a failure the loss would be less because of the equity finances. From the financier's perspective, the loss from the innovator's failure would be high, but the gains from successful innovators would also be high.

The expected profit from innovation for the firm should be non-negative, otherwise the firm would have no incentive in taking an equity arrangement, and an equity financier would not have an incentive to invest; hence, for the financier the equity share should also be positive. If innovation is successful, a firm would choose the output to maximise profit function:

$$p(e)[R(x) - C(x) - \beta\Pi(x)]^{14} \geq 0 \quad (11)$$

R(x) are the revenues of the firm, *C(x)* is the total cost and β is the share of the profit that would be repaid for the equity arrangement. However, as equity shares are paid after defining gross annual profits, the following equation is used:

$$\Pi(x) - E = R(x) - C(x) - E$$

Where $E = \beta\Pi(x)$, equity share as a certain percentage of the profit:

$$\Pi(x) - \beta\Pi(x) = R(x) - C(x) - \beta\Pi(x)$$

Hence, the expected profit would depend only on the effort of the firm:

$$E_{\pi}(e) = p(e)[R(x) - C(x)]$$

$$= p(e)[PX - C(x)]$$

$$= p(e)[(a - bx + \mu)x - (f + c + \varepsilon)x] \quad (12)$$

In the case where the innovator is risk-neutral, meaning a firm would maximise the expected value when the first order condition satisfies this condition,

$$R'(x) = C'(x) \quad (13)$$

$$(a + \mu) - 2bx = (f + c + \varepsilon) \quad (14)$$

This indicates the maximising values for quantity, price and profit are:

[14] For simplicity, the profit function for the firm is $\Pi(x) = [R(x) - C(x) - \beta\Pi(x)]$, where *R(x)=Px*, and inverse demand curve $P = a - bx + \mu$, where μ is the uncertainty (exogenous shocks) on the demand side, and $C(x) = f + cx + \varepsilon$, for the purposes of this essay $C(x) = (f + c + \varepsilon)x$, where ε is the uncertainty (exogenous shocks) on the cost curve.

$$x^{*}= \frac{(a+\mu)-f-c-\varepsilon}{2b} \tag{15}$$

$$p^{*}=\frac{(a+\mu)+f+c+\varepsilon}{2} \tag{16}$$

$$\Pi = P^{*}X^{*}-CX^{*}= b(X^{*})^{2} \tag{17}$$

Equation (17) confirms that the profit of the firm with equity financing does not depend on the equity share; hence, the equity share does not affect the cash flow of the firm, confirming results from Modigliani *et al*. (1958), that the finance structure does not affect the firm's value. The effect of the equity share is only how large a portion of the profits goes to the financier but does not influence the effort of the innovator or the output produced or the revenues. However, if the loss of ownership is added as well, the RCL model would be superior to the equity financing.

The expected utility from revenues and disutility from efforts do not depend on the equity share, hence no effect on:

$$E_{U}(E, R) = p(E)\, U(R) - V(E) \tag{18}$$

$$E'_{U}(E, R) = p'(E)\, U(R) - V'(E)= 0 \tag{19}$$

Equity financing does not distort the innovator's efforts or their decisions regarding the production process.

2.5.3 Revenue-contingent loan financing

With RCLs, the innovator would have to repay the principal plus the interest on the loan when the revenues are sufficiently high. For discounting purposes, it is assumed that repayment is a function of time. The revenues are uncertain each year and occur at different rates, hence the difference between the standard loan repayments with the contingent loan. The standard repayments would be constant over the repayment period, and the contingent would vary.

According to Modigliani and Miller (1958), the source of funding is irrelevant if it does not affect the cash flow. A contingent loan might be a more appropriate match for innovative activities, as innovations are followed by uncertainty, and a standard loan would impose a financial burden to innovators, leading to bankruptcy in many cases. All projects bear a certain standard risk that can be calculated and predicted. However, innovative projects on top of that risk, are uncertain and uncertainty cannot be calculated.

The expected profit from innovations for a firm should be non-negative, otherwise a firm would have no incentives in taking the loan. If innovation is successful, a firm would choose the output to maximise profit function:

$$p(e)[R(x) - C(x) - \alpha R(x)]^{15} \geq 0 \tag{20}$$

R(x) are revenues of a firm, *C(x)* is total cost and α is the share of revenues that would be repaid for an RCL.

It is assumed that firms are risk-neutral, and hence maximise their profit when marginal revenues equal marginal costs and profit maximising output is *x(r*).* This implies that profit is negatively related to RCL repayments, which are included in marginal costs and repaid before

[15] For the simplicity the profit function for the firm is $\Pi(x) = [R(x) - C(x) - \alpha R(x)]$, where *R(x)=Px*, and inverse demand curve *P=a-bx+μ*, where μ is the uncertainty (exogenous shocks) on the demand side, and *C(x)=f+cx+ε,* for the purposes of this essay *C(x)=(f+c+ε)x*, where ε is the uncertainty (exogenous shocks) on the cost curve.

other debt obligations, as government is a precedent claimant. Hence, the expected profit given innovator's effort *e* and cohort risk premium *r** is:

$$E_{\Pi}(e, r^*) = p(e)[R(x)-C(x)-\alpha R(x)]$$

$$= p(e)[PX-C(x)-\alpha PX]$$

$$= p(e)[(a-bx+\mu)x - (f+c+\varepsilon)x - \alpha((a-bx+\mu)x)]$$

$$= p(e)[((1-\alpha)(a+\mu) - (f+c+\varepsilon))x - (1-\alpha)bx^2] \quad (21)$$

In the case where the innovator is risk neutral, meaning the firm would maximise the expected value when the first order condition satisfies this condition:

$$R'(x)=C'(x)+\alpha R'(x) \quad (22)$$

$$(a+\mu)-2bx = (f+c+\varepsilon) - \alpha((a+\mu)-2bx) \quad (23)$$

This indicates the maximising values for quantity, price and profit:

$$x^* = \frac{(1+\alpha)(a+\mu)-f-c-\varepsilon}{(1+\alpha)\quad 2b} = \frac{(a+\mu)}{2b} - \frac{c}{2(1+\alpha)b} \quad (24)$$

$$p^* = \frac{(1+\alpha)(a+\mu)+f+c+\varepsilon}{2(1+\alpha)} = \frac{(a+\mu)}{2} + \frac{c}{2(1+\alpha)} \quad (25)$$

$$\Pi = P^*X^*-CX^*-\alpha P^*X^* = (1-\alpha)\, X^*(X^*b - \frac{\alpha(c)}{2(1+\alpha)}) \quad (26)$$

Equations (24), (25) and (26), show that with an RCL, if the share (cohort risk premium) is higher the produced quantity is smaller, and the profit is lower.

Still, the innovator would certainly not stop their cash flow in order to pay a lesser share for the RCL. Rather, the innovator would choose their effort to maximise their utility, as a difference between the positive utility from the revenue from the innovative project and the negative utility (disutility) of their effort. This is:

$$U(R) - V(E) \tag{27}$$

Assuming that investors are risk neutral, it is considered that marginal utility from revenues to be positive and non-increasing and marginal disutility to be positive and increasing:

$$E_U\,(E, R, \alpha) = p(E)\, U\,(R- \alpha R) - V(E) \tag{28}$$

For the maximised expected utility, the first order condition is:

$$E'_U(E) = p'(E)\, U\,(R- \alpha R) - V'(E)= 0 \tag{29}$$

Innovator's efforts are decreasing with an increase of the RCL rate (cohort risk premium or share), as this directly decreases the revenue. This agrees with the conclusions given in (26):

$$E\,'(\alpha) < 0, \text{ when } \alpha > 0$$

The innovator's effort moves in the opposite direction to RCL cohort risk premium rates. With higher rates, total revenues would be lower and have a marginal benefit of their effort; hence their efforts would decrease. With the opposite, with lower RCL rates, their efforts would increase, increasing total revenues.

RCL cohort risk premium contracts that would be offered to the innovators should lead to future potential non-negative cash flows. Further, if innovation is a commercial success, the RCL rate can be significantly small in comparison with the actual profit earned from commercialisation.

As the innovator repays RCLs only after successful commercialisation, the innovator until commercialisation does not have a moral hazard problem, as their efforts to develop and commercialise are not connected to RCL repayments until successful production and positive revenues start. Hence, it is assumed that the probability success is δp, for some $\delta \in [0,1]$

If *δ=1*, then the innovator exerts a full effort and there is no moral hazard. The moral hazard constraint is:

$$E\,\pi\,(e, r^*) = p(e)[R(x)-C(x)-\alpha R(x)] \geq \delta p(e)[R(x)-Cm(x)-\alpha R(x)]$$

Cm is cost from the innovator with moral hazard for which, due to the less exerted effort, the cost is less comparing to the cost with the full effort.

2.5.4 Including asymmetric information

In the above three scenarios, the assumptions did not include the asymmetrical information problem, where innovators have information that financiers do not have. Hence, innovators with different capabilities and efforts may not reveal them to financiers and choose any contract.

Myers (1984) and Myers and Majluf (1984) modified one of the most popular capital structure theories, the pecking order theory, which incorporates asymmetrical information. This theory states that if firms have preferences for their choice of finance, they will first use their internal finances, then debt, then equity. They also prefer safer over riskier external finances.

However, there has been a trend that small and high-growth firms with unestablished cash flow are still equity financed, which is opposite to what the pecking theory order states. Chang and Song (2013) found that this happens due to the financial constraints on small firms. Small firms often lack internal funds, and access to the debt market is often precluded because of lack of collateral and the perceived high risk and uncertainly of the venture by private lending agencies.

If access to finance wasn't a problem for firms, the pecking theory would have explained it perfectly, and debt would always come before equity as choice. As firms are constrained financially (especially the small and high-growth ones), they prefer equity, but the pecking theory still holds.

The proposed RCLs may well come before equity because government is a precedent claimant for revenues, while equity comes at a later stage, when dividends are payable from profits. With RCLs there is no loss of ownership as with equity. Regarding debt financing, it can be argued that RCLs might come well before debt, as RCLs do not require collateral; neither do RCLs possess fixed obligations.

However, some might argue that because RCLs bear higher interest rates due to the cohort risk premium rate, they may come after debt in the pecking order. As Stiglitz and Weiss (1981, 1983) have stated, even interest rates in private markets for loans are not optimal (that clear the market) primarily because of asymmetric information. Banks are aware of that fact and charge higher interest rates to compensate for potential higher risks.

Also, if government offers lower interest rates on loans than does the private market, many innovators would choose government loans instead of bank loans. This will lead to crowding out and not adding any extra innovation, as innovations would be financed by the private market in the first place. One of the rationales for government financing innovations is crowding in and financing only those projects that otherwise would have been left out by the private market; hence, maximising the social welfare.

In the last argument, reality has shown that small and high-growth innovative firms, due to lack of access to finance, would prefer equity rather than debt. With public RCLs, RCLs would come first in the pecking order for small and high-growth innovative firms.

2.6 Discussion

The main analysis presented in sections 2.4 and 2.5 consider RCLs as an alternative to financing innovation activity through debt (borrowing) or equity (through venture capital investment). This offers a neat extension to the existing 'pecking order' approach, which has primarily been concerned with modelling the innovator's preferences of one form of financing innovation over others (internal financing, debt, equity). And it offers a foundational analytical structuring , which integrates RCL as a further alternative. There are, however, a number of potential ways in which the modelling of the RCL could be compared with other different forms and interventions and usefully be extended in further research.

The present model is static and does not consider dynamics related to innovation cycles stages (Mazzucato and Semieniuk, 2017). Innnovations can be financed through the whole innovation chain. There are five stages of innovation development: the first one is the research where there is no tangible product yet and patent can be used to protect the IP rights; the second is when invention occurs and a functional product which serves as a good signal for many investors; after that stage comes the early development technology stage where the business development occurs and attracts further investors. The next stage is the product development stage on a large scale establishing the new innovation which ends with the last stage of the innovation cycle which is having a viable innovative business with mass production of the innovative product. Different financing instruments can be associated with various growth stages of start-ups and different types of investors are attracted to invest at different stages of the innovation cycle, but the riskiest ones are the first two and, in order to fill in the financial gap, RCLs are suggested as the main focus of this thesis.

Future research can compare RCL to other traditional forms of government intervention through a mix of direct and indirect financial instruments. Direct support is offered through grants, loans, equity financing, public procurement for R&D, technology consultation services and innovation vouchers (OECD, 2014). Indirect public funding is given through the tax incentives. Grants are the most spread public financial instrument, granted on competitive basis predominantly to start up. They are discussed and compared with RCLs in detail in the next Chapter 3.

Government debt financing can be through credit loans – they are subsidised and require repayments and a collateral; loan guarantee- the government actually does not finance but gives guarantee to the firm to signal the creditworthiness to the bank. Governments' mezzanine funding is usually used at later stages of firms' cycle with a strong cash position, and incorporates both debt and equity financing as it is a combination of several financial instruments. Government can act as a venture capitalist as well through its institutional investors such as public funds[16]. The principle is the same as in the case with private VC funds,

[16] For ex. Venture Capital Support Programme in Turkey, Corporate Venture Programme in France or COSME-Equity Facility for Growth in EU.

just we have here the government who as investor has equity in the firms, making them public-private partnerships. In some countries even business angels, who provide not only financial support but also expertise and mentorships in return for an equity in firms, are organised through governments (such as the Business Angel Programme in Spain, Business Angels Co-Investment Facility in Netherlands etc).

Government can finance innovations through public procurements creating a demand where it is needed, but do not exist especially in the areas such as defence where the governments will retain the intellectual property rights while the research results will belong to the innovators (Guellec and van Pottelsberghe,2000). Government can also give innovation vouchers to firms to purchase selected services from public knowledge providers. In addition to all above mentioned direct public financial instruments, which are more targeted towards long-term research, indirect public instruments through tax arrangements are targeted at short-term research and to boost innovation spending rather than breakthrough radical innovations. Those are discussed in detail in Chapter 3 as well.

With fast developments in the field of digital financing, RCLs shall be further compared with other financial options in private capital markets such as Business Angel Networks, Crowdfunding[17], or Initial Coin Offerings[18] (Kgoroeadira & Burke & van Stel, 2019; Klien et al, 2019). Those novel financing ways are enabled due to the existence of the Internet and social media as new communication methods.

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[17] Crowdfunding is an alternative way of financing through raising small amounts funds for a project from large group of people via the Internet.
[18] Initial Coin Offerings are an alternative way to finance cryptocurrency projects and by-pass the standard capital market regulations. Investors can buy the offering and receive a new cryptocurrency token issued by the company.

2.7 Conclusion

Innovations are crucial for economic growth; hence, governments try to improve the economic performance of their countries by stimulating innovations, particularly in the SME sector. The innovative entrepreneurship sector, regarded as the engine of job creation and innovations, however, faces huge financial constraints, making this area one of the biggest concerns of governments in creating appropriate policy for the economy.

This essay has discussed an alternative form of financing innovation, the revenue-contingent loan, which is not readily available on the private market for all innovative entrepreneurial firms. Government could fill this gap, providing RCLs to innovators, charging them a cohort risk premium interest rate. Governments would have two advantages for RCLs over private markets: transactional efficiencies and precedent claimant. Hence, instead of financing business innovations through grants, RCLs might be a better option for governments to support more firms. To bridge this knowledge gap, Essay 2 (Chapter 3) of this thesis will next investigate if policy and budget implications change with different scenarios for proposed RCLs.

This present essay (Chapter 2) has further shown that although innovators' efforts are affected by RCLs, and not by debt and equity, and if asymmetric information (a market failure and one of the rationales for including a government in innovations' financing) is included, RCLs might be in first place in the pecking order theory for young and small high-growth innovative firms. More research should therefore be done, preferably with simulations to prove this proposition.

This present essay has shown the potential attractiveness of RCLs for governments, although the details must be carefully determined in future policy work. RCLs are innovative public financial instruments for financing business innovations that governments should start using if they want sustainable financing and budgeting, while financing more innovators. Governments might start to think more as risk managers and entrepreneurs if sustainable economic growth achieved through innovations is their goal.

Chapter 3 Estimating government subsidies with revenue-contingent loans for business innovations in Australia

3.1 Introduction

The main research question of this chapter is: what are the consequences of different aspects of RCL design with respect to government subsidies? The objective of this research is to illustrate how the Government would benefit from moving away from grants, and to what extent taxpayer money would be saved, by calculating the value of government subsidies[19], as a percentage of the value which the firm borrowers do not repay in comparison to the 100% subsidies associated with grants.[20] This chapter presents simulations of repayment rates by borrowing SMEs under different RCL parameters. For each firm, repayment patterns might be different, hence it is individual revenue profiles and repayments over their entire business life-cycle that need to be simulated.

Compared to grants, RCLs offer the prospect of a return to the taxpayer from the outlay. Therefore, the repayment patterns are central to the case for the use of RCLs as an alternative, or as a complement, to traditional assistance through grants.

This analysis contributes to the literature by using a sample of Australian firms with data from the Australian Bureau of Statistics (ABS). The approach taken follows a plethora of comparable applications which illustrate the implicit subsidies associated with income-

[19] They include non-repayment due to bankruptcy and interest rate subsides.

[20] The focus is on a comparison of Australian government grants and RCL, and not a broader comparison that also includes government business loans, which could be a topic of future research.

contingent loans to higher education, with there being two steps in the methodology. The first step uses various techniques to estimate the expected future revenue streams for firms, differentiated by their employment size and their historical levels of annual revenue, to apply predictions to RCLs. The second step investigates the extent to which the choice of different parameters for the scheme (e.g. levels of debt, interest rates, repayment rates, debt surcharges, grace periods), affects loan subsidies. The analysis uses static microsimulation modelling to estimate the impact of RCLs upon firms without extensive behavioural adjustment over time.

Innovation is considered a key driver of economic growth on a macroeconomic level. On a microeconomic level, innovation helps firms achieve competitive advantage in the market. However, markets fail to achieve optimal levels of innovation activities. As explained in detail in Essay 1 (Chapter 2), due to various market failure problems, there is private market underinvestment in business innovation from the viewpoint of social welfare, thus giving a rationale for government support for business innovation.

The Australian Government has correspondingly intervened in the business innovation market for decades. Currently, there are many financial schemes for business innovation (OECD,2014) in Australia, ranging from indirect financial instruments, such as the R&D Tax Concession, to direct financial instruments, such as grants. However, these instruments can result in a substantial transfer of taxpayer money to firms without achieving the goal of increasing overall business innovation, firm productivity and social returns, depending upon how cost-effective the instruments are. There can be deficiency in policy design ('collective failure'), just as there can be market failure. There is an obvious need, therefore, to assess whether potential exists for more a desirable policy which would drive new levels of innovation by mitigating the limitations of the current policy.

Various reforms have been undertaken in recent years as explained more in section 4.3 in Chapter 4, but more may be possible. Arguably, RCLs are a highly useful alternative public financial instrument to promote business innovation in Australia.

Moreover, there is a distinctive Australian contribution in the field of loans where repayment is contingent on the recipient's ability to repay rather than on a set time schedule, as with income-contingent loans (ASSA 2019, pp. 13–15). This essay builds on earlier work and scheme design and operation of ICLs for higher education, and examines utility for a new innovation assistance role. For the purposes of administrative accuracy, RCLs are used rather than ICL, since here it will be assumed that the debt will be collected from the firm's future revenues. The author considered RCLs rather than profit contingent loans in order to minimise potential moral hazard that might arise in cases with profit calculations. Under this proposed scheme, firms may borrow from the government to finance their innovative activities, but repayments will be contingent on each firm's future revenues. This particular scheme was first proposed by Dadd and Withers (2005), with the collection issues explained in Botterill *et al.* (2017), although the idea has yet to be adopted by policy makers.

The initial static model can be further extended into a dynamic model by recognising and allowing firms to change their characteristics over time due to many endogenous factors in the model and by distinguishing between transitory and permanent components of revenues.

The RCL designs described in this essay are for illustrative purposes only, and not for final policy implementation, with none a preferred design yet for implementation. Rather, the results are shown for public policy debate so that the extent of trade-offs between different policy goals can be compared to alternative financing instruments. No known prior research has explored RCLs in the Australian context in this way.

This study attempts to fill that gap and provides estimates of the potential size of the subsidies associated with different design of RCL for Australia. It is emphasised that if the comparator class of innovation policy are grants, the associated subsidies constitute 100% of the grant size. As such, an RCL approach to government intervention has the potential, if designed properly for full and precise implementation, to allow lower-cost sustainable financing of Australian firms for business innovation.

This paper thus does not aim to present a cost and benefit analysis of the newly proposed scheme. While the description of the characteristics of firms and the estimation of effects of RCLs on firms and government revenues are part of cost and benefit analysis, there are a number of other issues that are not covered in this essay. These include the analysis of social costs and benefits, the effectiveness/efficiency of proposed scheme delivery and administrative arrangements. The aim is to present a case to establish that RCLs should be considered as a part of the portfolio instrument choice analysis in future innovation policy review and revision.

This essay (Chapter 3) is structured for this purpose as follows. Section 2 provides an overview of financing business innovations in Australia as background so as to understand the nature and strengths and weakness of innovation and innovation policy in Australia. Section 3 explains the relevance of RCLs to business innovation policy, given this background context. Section 4 explains the data and methodology used to affirm quantitatively the dimensions of the operation of such RCLs as a potential contributor to support for innovation. Section 5 provides revenue distributions which are used in Section 6 to present the simulation results for different parameters of the design for such RCLs. Section 7 discusses the effects of different parameters in such design. Section 8 concludes the essay by summarising major findings regarding the potential for consideration of RCLs for innovation support in Australia, given existing arrangements, and then examining how RCLs might broadly operate based on simulation of such RCLs on actual corporate data.

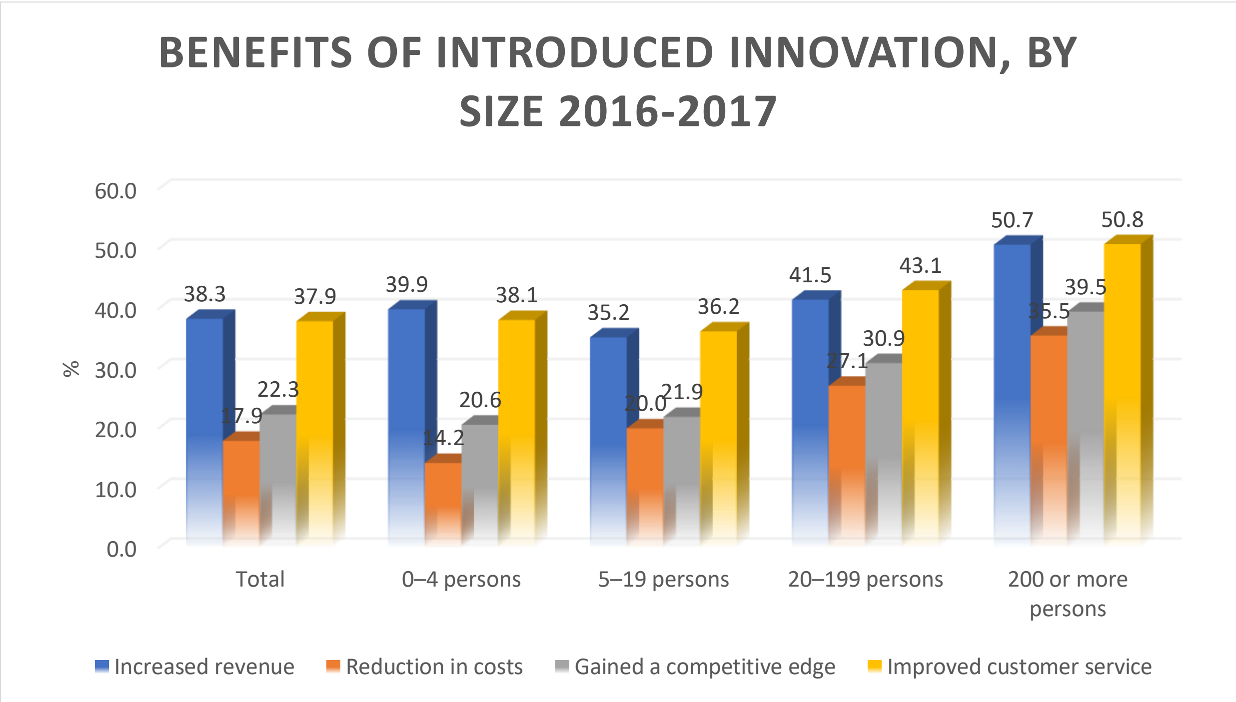
3.2 Financing business innovation in Australia

To understand the relevance of RCLs, the background context of business innovation policy in Australia is presented in this section. Innovation is seen as a key driver of economic prosperity, but why is innovation so important for firms? Figure 3.1[21] presents the business perceptions of the benefits of implemented or introduced innovation by firm size (proxied by employment size). For all firm sizes, innovation leads mostly to improved customer services and increased revenues. More than one third of small and medium enterprises (SMEs) stated that their revenues increased after the implementation of innovation, and approximately one fifth of all micro and small firms gained a competitive edge. Apparently, innovation enables firms to establish competitive advantage in anticipating market opportunities, through either

[21] The data used in this section is from ABS (2016–2017) population tables, cat.no.8166.0.

efficiency[22] or effectiveness[23] of input use. According to Shanks and Zheng (2006), private returns for the firm are generated through reduced costs, increased profits and improved productivity. In Figure 3.1, reduction of costs is noted as one of the benefits and was proportional to the firm size: the larger the firm, the higher reduction in costs experienced.

Figure 3.1 Benefits of introduced innovation, by size (2016–2017)



Source: ABS (2016-2017), cat. no. 8166.0.[24]

However, social returns are greater than private returns, as explained in detail in Essay 1 (Chapter 2). Hence, this is one of the rationales for government supporting business innovations. Almost a third of all innovative-active businesses in Australia reported access to

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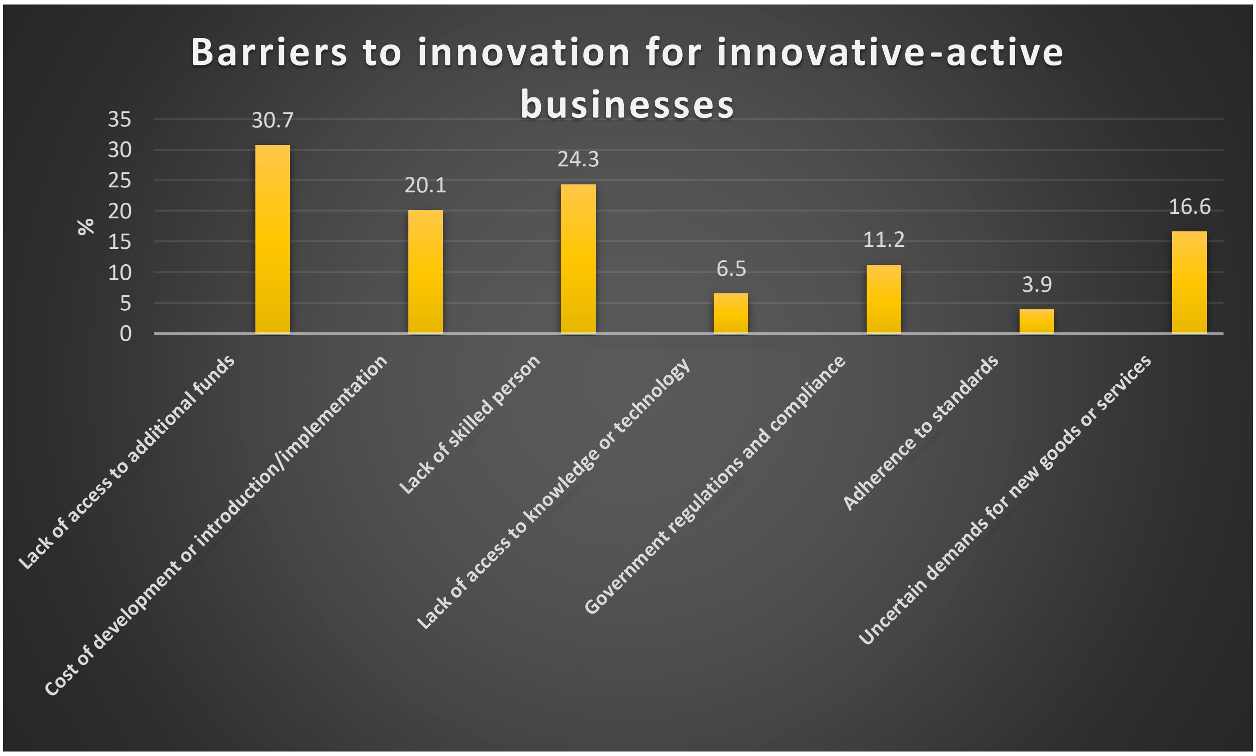
[22] Less inputs to produce the same unit of output.
[23] Same amount of inputs will yield greater output.
[24] The information presented in this section are largely based on the 2016–2017 Business Characteristics Survey (BCS), conducted by the ABS, which contains the most updated information on innovation in Australian firms.

finance as the greatest barrier that hampered their innovation efforts (Figure 3.2), followed by lack of skilled persons and cost of development or introduction/implementation of innovation. Australian finance system might be a barrier here, too, as it is highly concentrated, and only a few banks dominate the financial sector (RBA 2007).

Figure 3.2 Barriers to innovation for innovative-active businesses (2016–17)



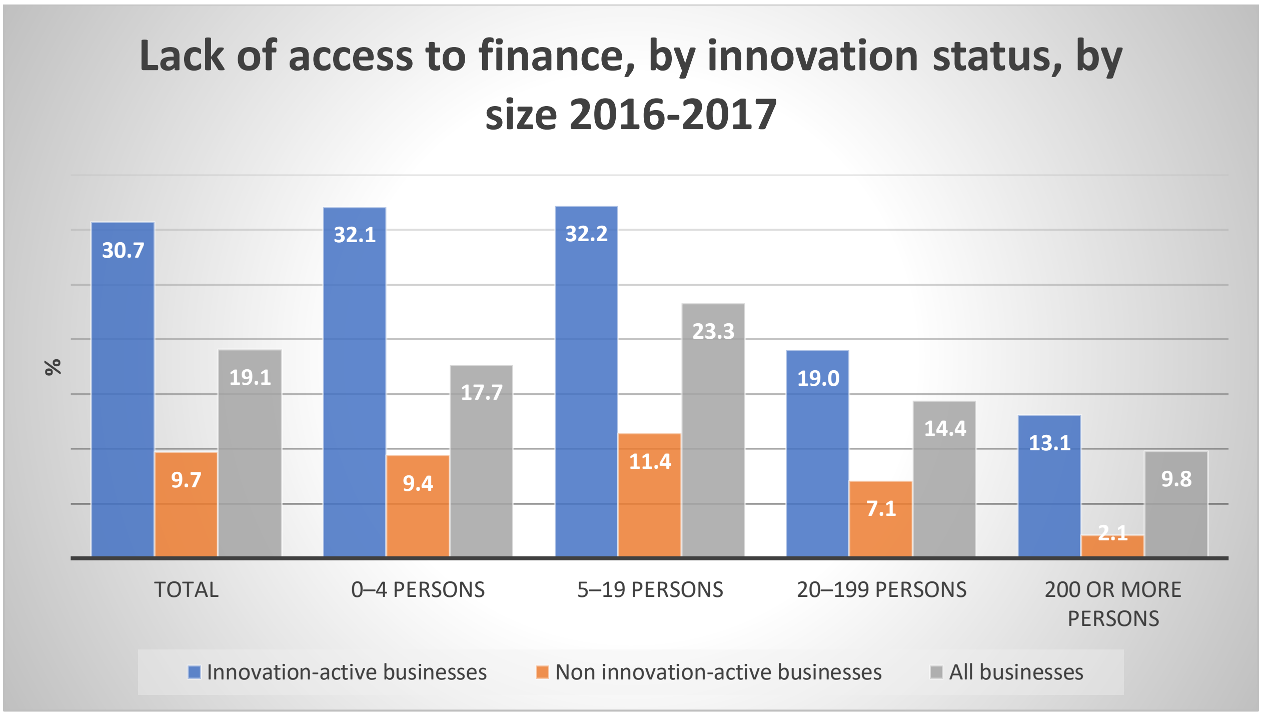
Source: ABS (2016–2017), cat. no. 8166.0[25]

Availability of finance for innovative firms in Australia varies across sectors and firm size. Figure 3.3 provides evidence that innovative firms have almost three time more issues with access to finance than the same size non-innovative firms. The lack of access to finance is

[25] Ibid 3.

largest for micro and small firms, at around 32%, and smallest for medium and large firms (at 19% and 13% respectively).

Figure 3.3 Barriers to innovation, by innovation status, by employment size (2016–17)

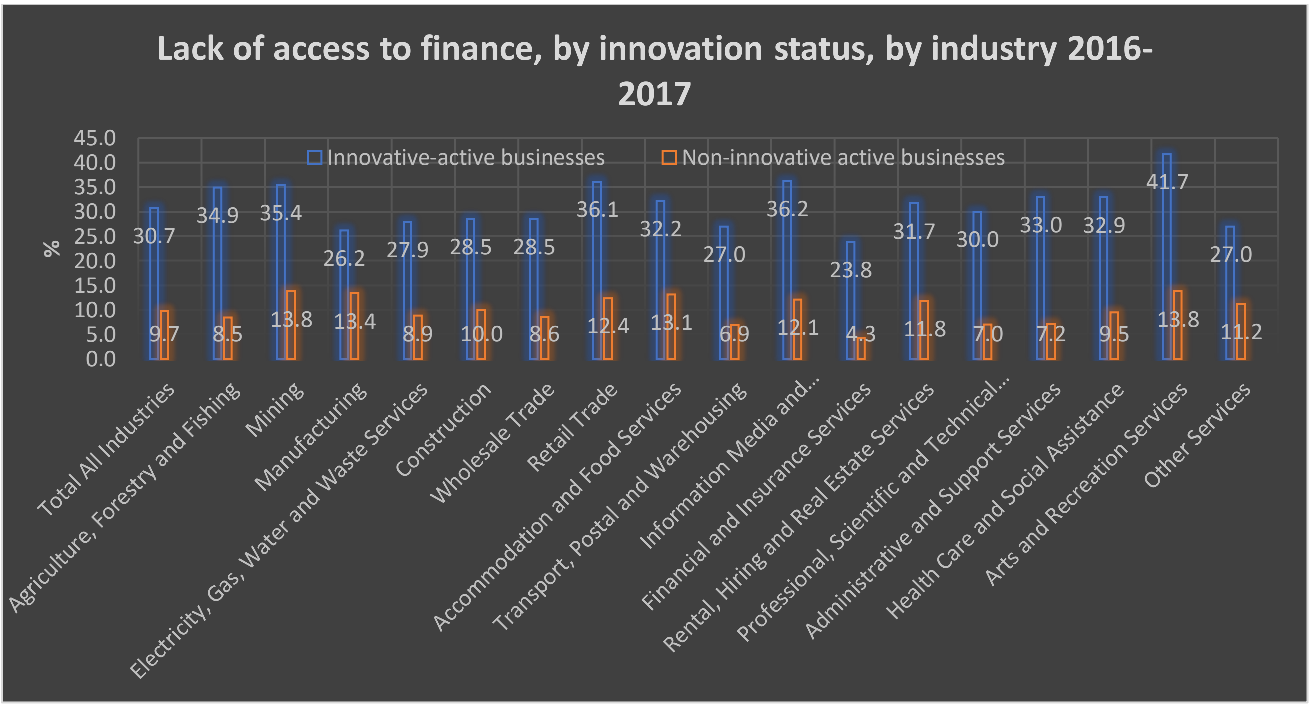


Source: ABS (2016–2017), cat. no. 8166.0

Innovative firms reported a higher need for finance across all industries compared to non-innovative firms (Figure 3.4). Among different industries, firms in the arts and IT sector reported the highest issues accessing finance, perhaps due to lack of tangible collateral, while manufacturing had one of the lowest, with those industries having plant and equipment that can be used as collateral for secured debts on the private lending market.

The need for financial assistance also varies widely depending on the costs associated with the development of different types of innovation depending on the industry in which the firms are operating. For example, the relative costs of medical devices, therapeutics and different health technologies can vary significantly. Also, it is useful to have data on a firm's location to see if barriers to finance vary at the spatial level, especially for micro and small firms, to estimate whether being geographically away from financial hubs has a proportionally larger impact on access to finance.

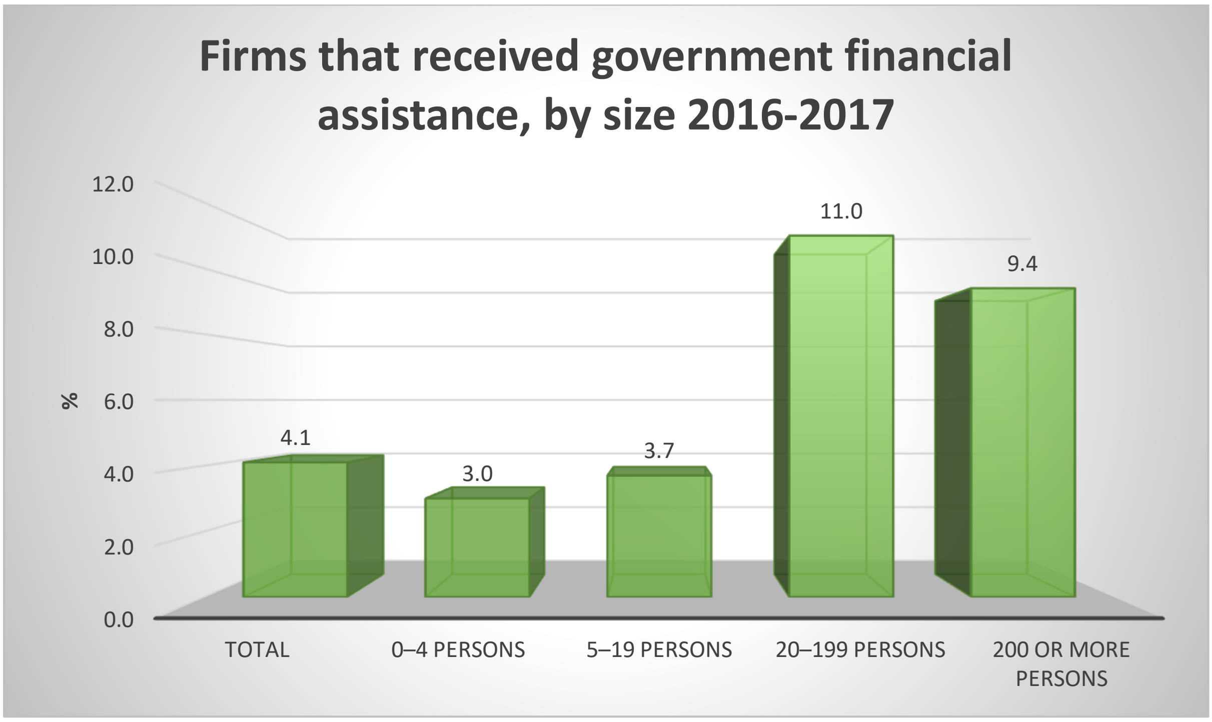
Figure 3.4 Lack of access to finance, by industry (2016–17)



Source: ABS (2016–2017), cat. no. 8166.0

Although firms that need access to finance the most are micro and small firms, from Figure 3.5 it is noticeable that firms which actually received government financial assistance for innovation were 11% of medium firms and 9.4 % of large firms. Large and medium firms access government financial assistance more than any other firm size. Only 3% of all innovative small firms received any government financial assistance. There may therefore be certain characteristics that are more amenable for participating in a government scheme, such as the firm size. This imbalance may reflect a lack of awareness by small firms of what financial support is available. Small and micro firms generally do not have the necessary resources to investigate and navigate all the available support opportunities. Small innovative firms that are actively working in high-paced markets and doing R&D do not have time to follow and adapt constantly to the continued policy and administrative changes, as in the case with the R&D incentive and grant schemes. The larger a firm, the bigger comparative advantage it has in dealing with government, for conventional schemes, as they have teams which manage government interactions and prior established working relationships. Further, larger firms can spread the cost of applications over a bigger subsidy. These are essentially economics of scale and scope in grant application activity.

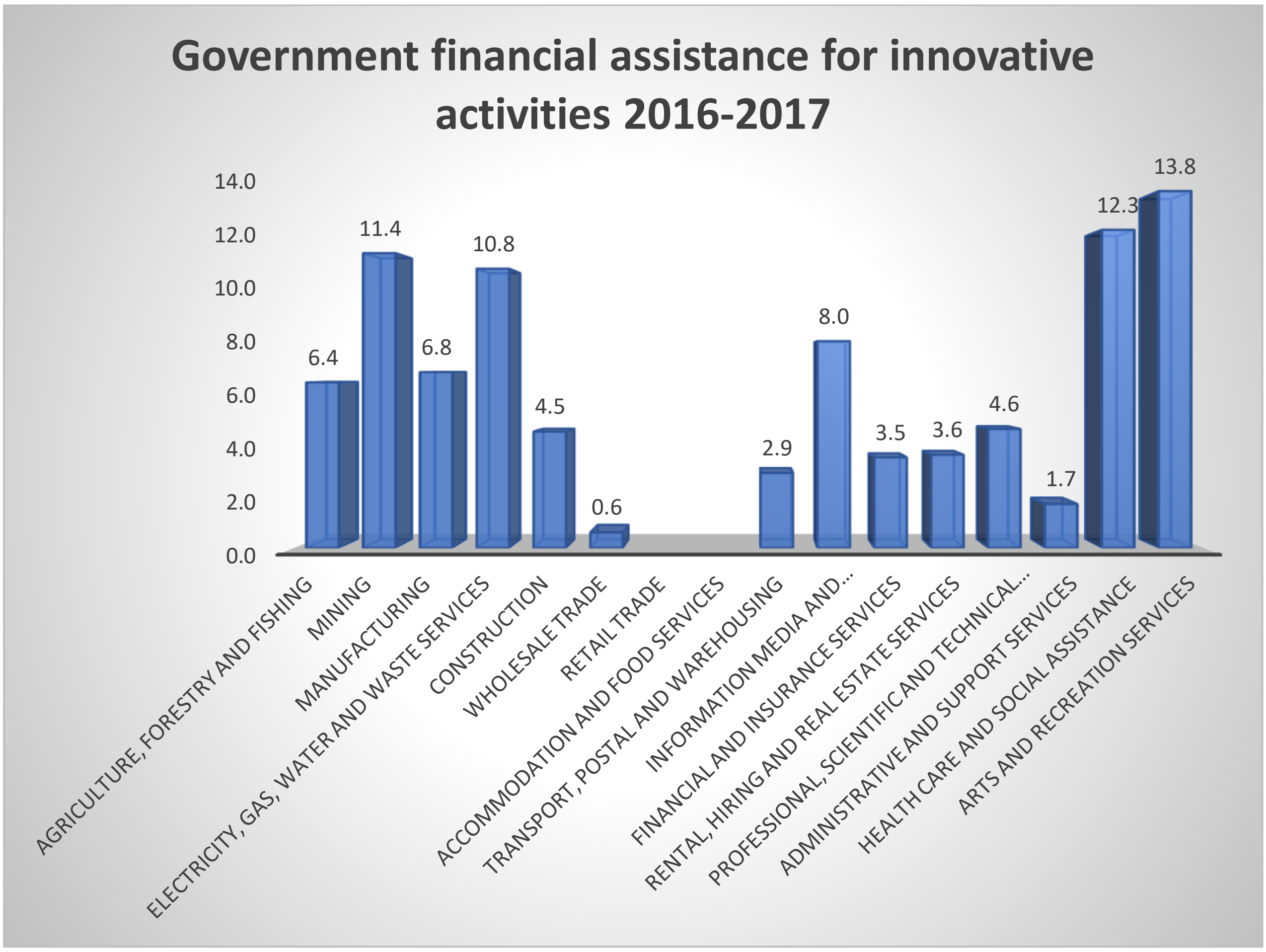
Figure 3.5 Firms that received government financial assistance, by size (2016–17)



Source: ABS (2016–2017), cat. no. 8166.0

Figure 3.6 reports the percentage of innovative-active firms that received government financial assistance across different industries. According to the firm's needs, as presented in Figure 3.4, firms in arts and services reported biggest issues with access to finance and they received the largest government support to overcome those issues. After them, firms operating in health care and social assistance sectors, and in mining, received government financial support with 12.3% and 11.4% participating respectively. Firms who received the least government financial assistance were from administrative and wholesale trade industries.

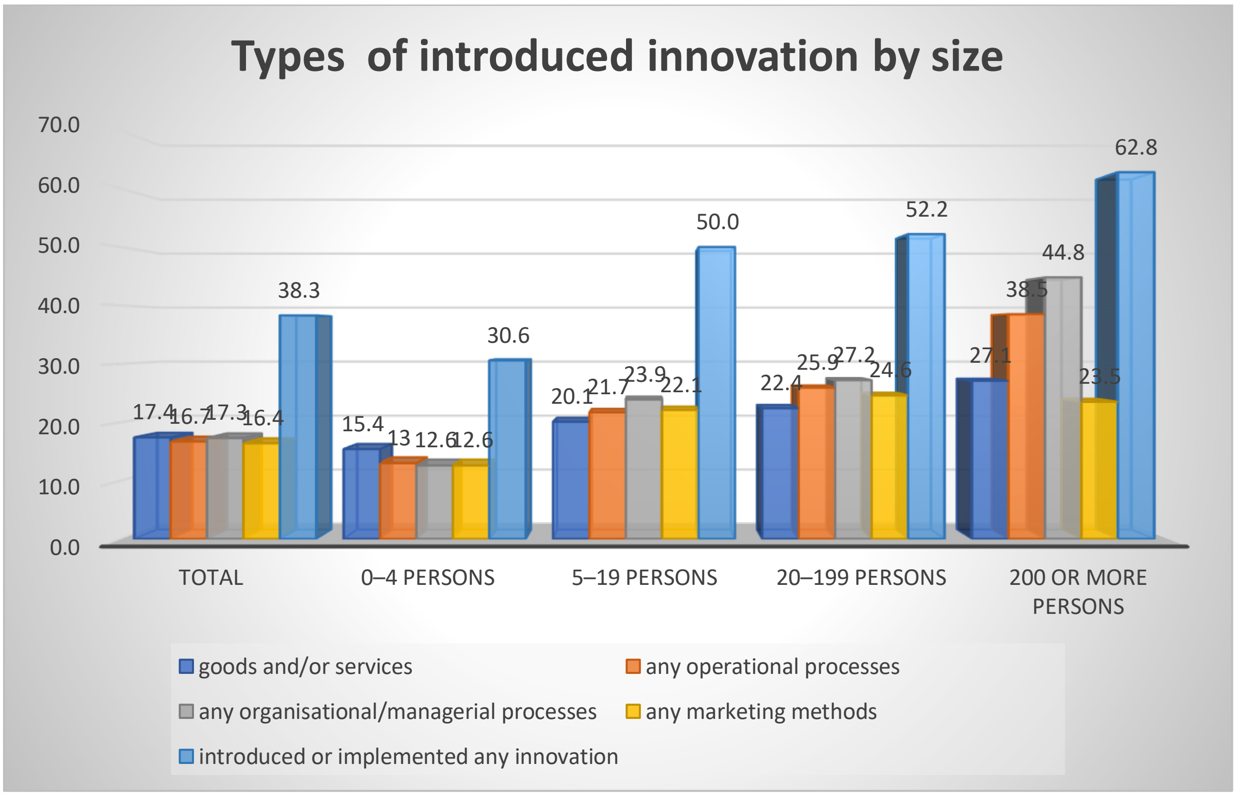
Figure 3.6 Government financial assistance for innovative activities (2016–17)



Source: ABS (2016–2017), cat. no. 8166.0

The distribution of innovative activity across firm size is presented in Figure 3.7. During the five years ending in June 2017, innovation was undertaken by 38.3% of all firms. About 17.4% introduced new or significantly improved goods or services; 17.3% implemented new organisational and/or managerial processes, a slightly smaller portion (16.7%) implemented operational processes innovations, and 16.4% of all firms introduced new or improved marketing methods. In terms of firm size, the propensity to innovate increases with size, ranging from 30.4% for micro firms to 62.8% for large firms. Large firms generally have greater financial resources available to them for innovative activities. For micro firms the largest portion of innovation was new or significantly improved new goods and/or services. As firm size increased, so did the propensity to focus and innovate the organisational and managerial processes.

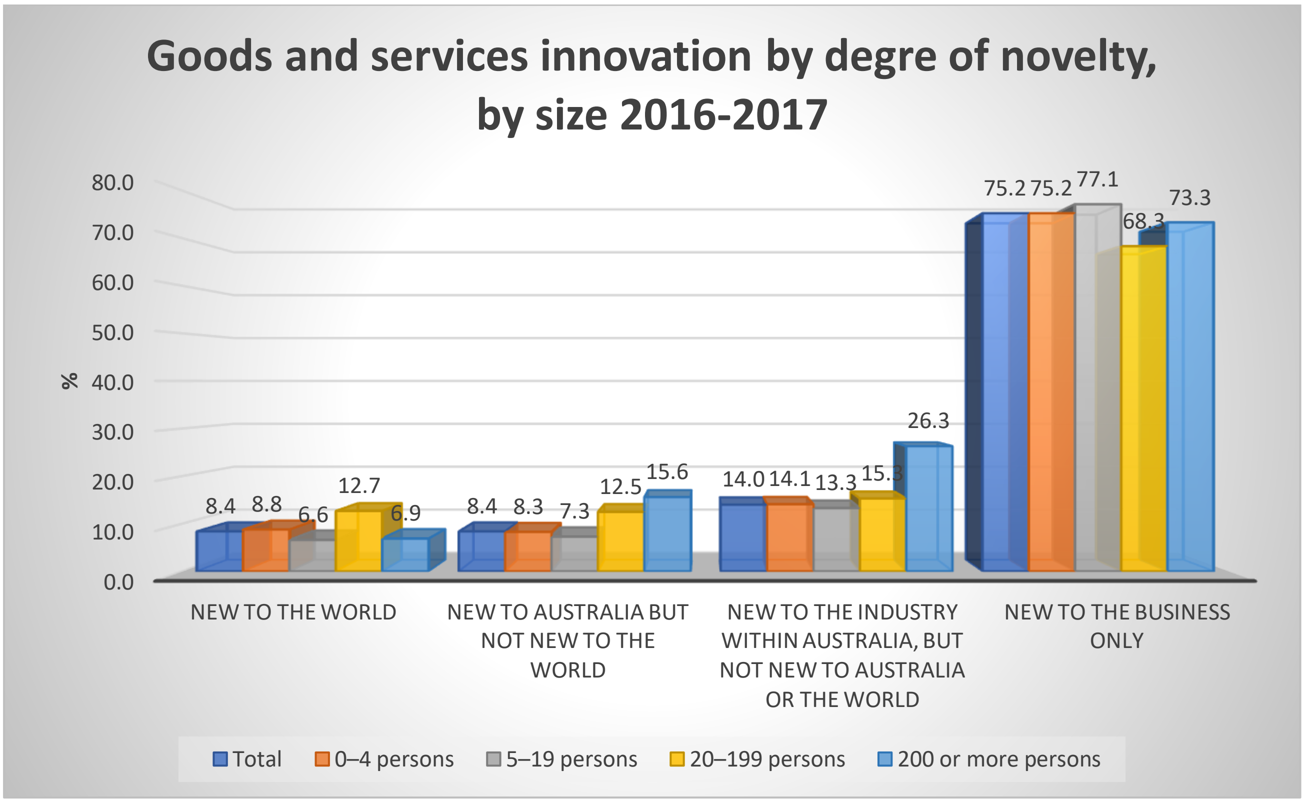
Figure 3.7 Employment size and types of innovation introduced (2016–17)



Source: ABS (2016–2017), cat. no. 8166.0

Figure 3.8 shows the novelty of goods and/or service innovation by firm sizes, whether the innovation was 'new to the world', 'new to Australia', 'new to the industry' or 'new to the business'. Some 75.2% of all firms had 'new to the business' innovation as their highest degree of novelty, while only 8.4% had 'new to the world' innovation. However, medium and micro firms had introduced more 'new to the world' innovations than large firms.

Figure 3.8 Goods and services innovation by degree of novelty, by size 2016–2017



Source: ABS (2016–2017), cat. no. 8166.0

Innovations at different stages of development might require different types of financial support. For example, financial needs might be different during stages of innovation development (feasibility studies, testing, development of a prototype, etc.) and commercial development (pre-revenue, break-even, profit making etc.).

3.3 The relevance of revenue-contingent loans to business innovation policy

Small firms in Australia account for almost 98% of all firms (Table 3.1), employing 44% of total Australian workforce and accounting for almost 35% of total Australian gross domestic profit (ASBFEO 2019).

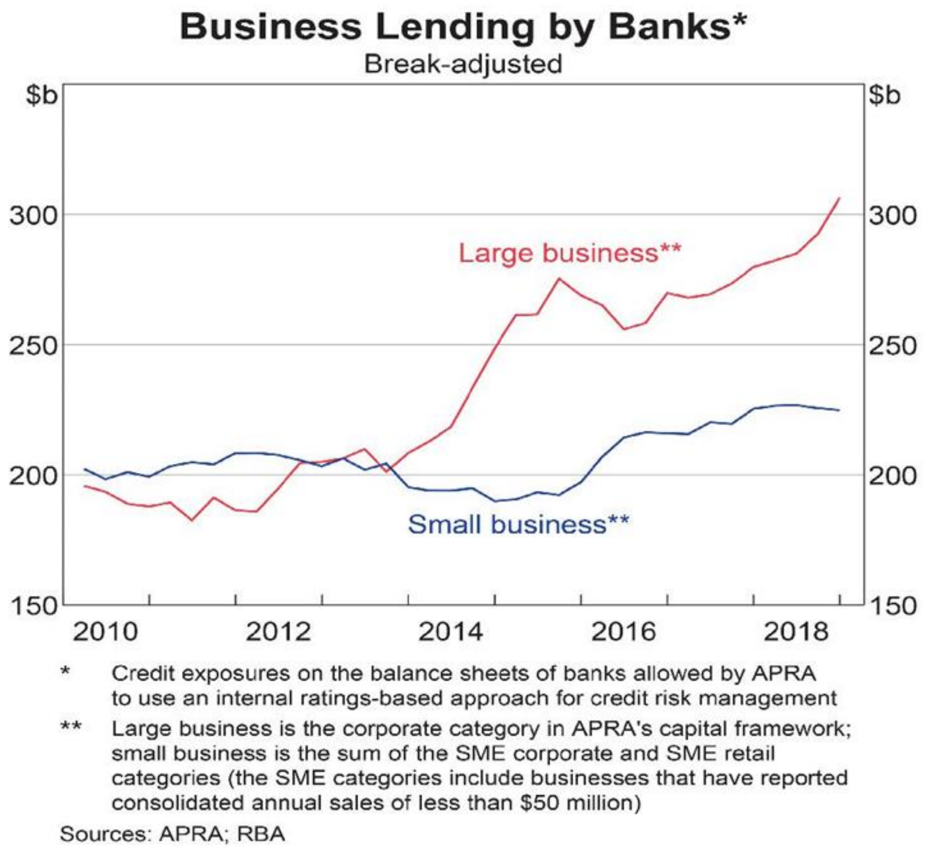
Table 3.1 Firm count by size (2019)

Employees	Firm Count	%
0–19 (small)	2,259,098	97.7%
20–199 (medium)	50,338	2.2%
200+ (large)	3,855	0.2%
Total	**2,313,291**	**100%**

Source: ABS Counts of actively trading Australian Business with an active ABN 8165.0, Table 21 Feb 2019

Despite their importance to the Australian economy, financial resources on the private lending market for small firms constantly trail lending to large firms. Figure 3.9 reports that in the past decade, bank lending to large firms increased 50% while lending for small firms increased less than 12%. Although small firms might have an advantage in terms of flexibility, and ability to promote creativity and innovation, they experience greater difficulties in gaining access to finance, and availability of finance is a crucial determinant of a firm's investment in innovation (Ozkan 2002). Without the necessary financial resources, underinvestment in innovation persists.[26]

Figure 3.9 Business lending by banks in Australia to small and large businesses (2010–2018)



How should Australian government policy address underinvestment in innovation? And are the current public financial support schemes for Australian business innovation effective? Although there are various policy approaches, this study discusses a particular kind of public contingent loan, the RCL, that might be able to alleviate capital market imperfections.

[26] Reasons for underinvestment in innovations are explained in greater detail in Essay 1 (Chapter 2) of this thesis.

The idea of applying RCLs for business innovation stems from the ICL system used in higher education, a concept first proposed by Bruce Chapman in 1989. Since its introduction in Australia, initially as the Higher Education Contribution Scheme, then later renamed the Higher Education Loan Program (HELP), the concept of contingent loans to finance education has had broad success as a policy instrument worldwide and HELP-style systems have now been put in place in many other countries including New Zealand, United Kingdom, Korea and Hungary. While ICLs work for financing higher education student loans, it is also possibly a viable additional financial instrument in many other areas of economic importance. This potential has been recognised by many other researchers as is seen where similar applications have been proposed in many areas, such as financing paid parental leave, rent relief for social housing, and drought policy (Chapman 2006; AJLE 2009).

In relation to business innovation, the rationale for government support of innovation, and bringing it to optimal levels, have been explained in Essay 1 (Chapter 2) of this thesis. Innovative firms usually are unable to borrow money sufficiently from the private lending market financial institutions, due to lack of collateral. The argument for RCLs is also based on the assumption that such innovations unrealised have externalities, and spillovers to society which make the social returns higher than the private returns (Arrow 1962), leading to private underinvestment occurring as the gains cannot be fully appropriated by the firms.

With RCLs, a firm's repayments are adjusted according to their revenues, providing the firm borrower with an insurance function. This benefits revenue smoothing, which is otherwise inhibited by imperfect capital markets. In other words, the revenue-contingent nature will make debt repayments resemble dividend payments. RCLs were compared with traditional financial options, such as debt and equity financing in Essay 1 (Chapter 2), and their implications on innovator's effort and profit functions. Further, in Essay 1 it was discussed why RCLs cannot as readily come from the private lending market, as from the public sector.

Here, a comparison is made between current government assistance in Australia and newly proposed RCLs. In this thesis, government refers to federal and state government and local, national or international government agencies. Government assistance is defined as any government financial action for providing economic benefit to firms qualifying under certain criteria.

Government financial assistance takes many forms, varying both in the nature and the target of the assistance given. By the nature of the financial assistance there are two main financial instruments available: direct assistance (grants and loans) which provide up-front financial support to firms; and indirect assistance (such as tax incentives) which refund part of certain expenditures. Regarding the scope of target of financial assistance, all financial instruments can be divided into general or selective. Before deciding upon the appropriateness of certain financial instruments, good governmental practice would require that a cost–benefit analysis be carried out, comparing the future social returns with capital, administrative and compliance costs, and allowing for rent seeking inefficiencies in the programs proposed.

Current grants and RCLs as direct financial instruments should be evaluated in terms of their costs and benefits. Grants here are financial assistance by government to a firm in return for compliance with certain criteria of the firm's operating activities. Grants are 100% subsidies or subventions, as no repayments are required. In Australia, competitive, merit-based matching grants[27] are given to firms for business innovation.

RCLs are revenue smoothing risk management tools and protect the firms against financial hardships they might experience with traditional mortgage-type loans. However, countries without grants may hesitate to allow universal access to RCLs due to concerns about their possible damages on fiscal health. As grants are merit based, but decisions are discretionary without explicit criteria for selection, it can be assumed that government decision-makers target those applications with highest social payoff, which otherwise wouldn't be financially supported. In practice, however, it might be difficult to predict the social benefits of all alternative applications and weigh them. Grants need not require collateral, making this option particularly well suited for SMEs and new firms, and an advantage of grants over loans is that they may reduce the administrative costs, as grants don't require the collection of repayments.

There are disadvantages of grants in comparison to RCLs First, as there are no repayment obligations, grants might attract more rent-seeking firms, increasing the risk of crowding out of public investments. Second, as taxpayer money is limited, reaching scope is limited as well, concentrating on a small number of firms who receive government assistance. Third, grants cannot increase the aggregate amount of financial resources, as there are no direct repayments. Once the grant is paid, there is no direct return to government. Fourth, grants cannot help firms build up a credit reputation for future lending from the private market.

[27] The grant scheme was examined in Essay 1.

Although grant expenditure is not recovered immediately, it is still expected that in the long run for successful projects, recovery of the finances should be made through higher revenues from corporate taxes, though this applies to loan assistance too.

Although it can be argued that grants have less administrative costs compared to RCLs, RCLs still have the advantage of ‘transactional efficiencies’, or administrative simplicity, as the information required for calculating repayments is already being collected by the Australian Tax Office (ATO), transactions are done online and managed through the Business Activity Statements (BAS) system like pay as you go (PAYG) company tax. The most desirable government assistance for supporting business innovation should maximise social benefit though maximising support available while minimising costs of intervention through overcoming drawbacks on current schemes, as well as drawbacks that might arise with the use of RCLs.

Thus, it can be argued that RCLs could be a powerful public direct financial instrument able to provide effective outcomes which, as previously explained, cannot be achieved with other public direct instruments such as grants. The appropriate design of RCLs is of crucial importance for their success. Ultimately, any government financial assistance involves substantial transfer of money from taxpayers to firm recipients. As successful firm recipients over time are likely to be wealthier than the average taxpayers who funds their initial innovative idea and project, properly designed RCLs might present a fairer alternative to existing government grants with no repayment obligations.

An important question to be raised in the design of RCL is who should carry the loss of non-repayments, taxpayers or the cohort (through paying a risk premium interest rate and/or loan surcharge)?

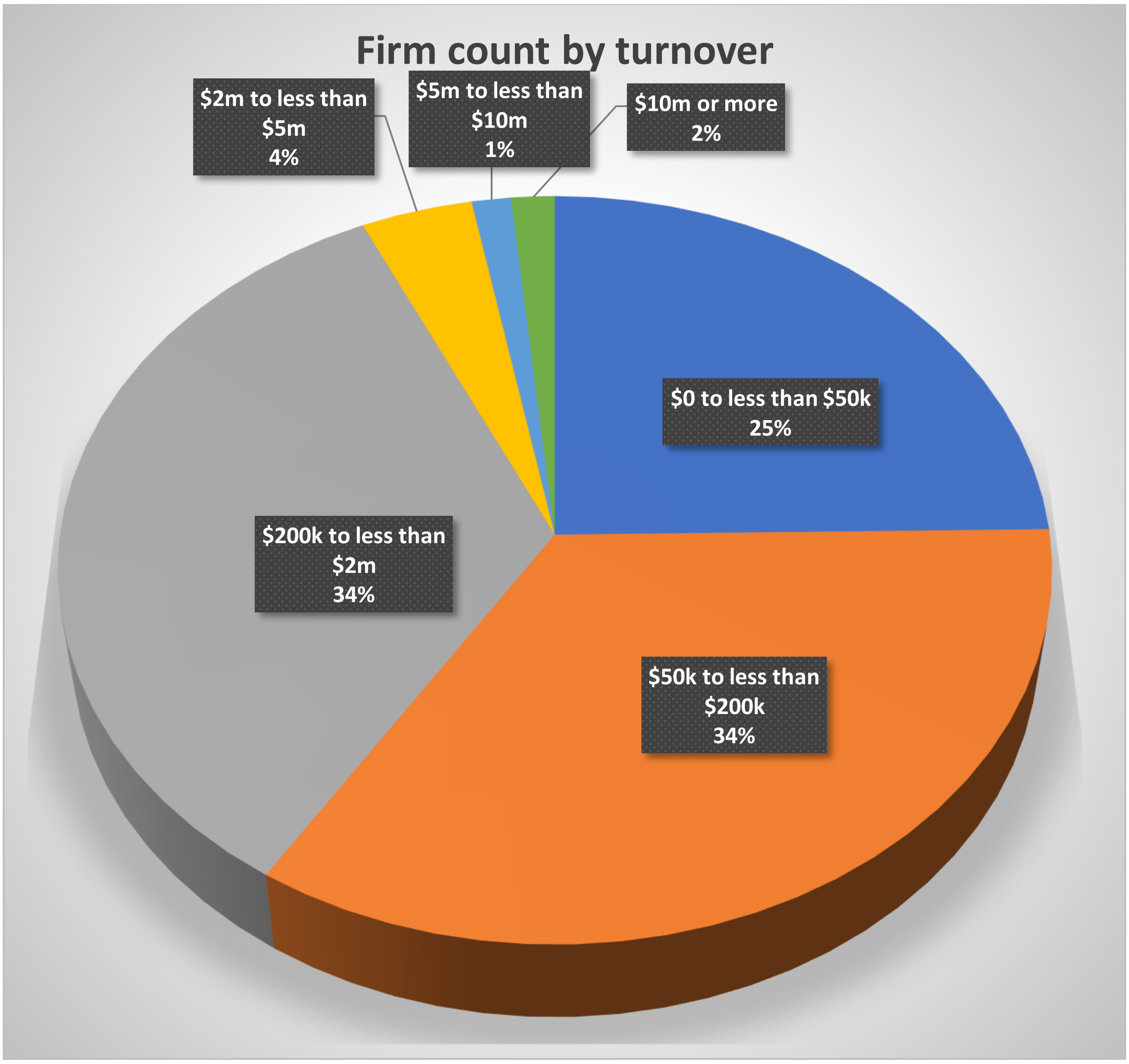
As discussed by Barr *et al.* (2019) for ICL design, the issue arises especially with larger loan amounts, which might be the case with RCLs. RCLs, unlike ICLs, can be an addition to and/or completely replace the existing grant scheme for business innovation in Australia which is a 100% loss (as no repayments are demanded), completely to taxpayers. That lowers the available financing pool for firms in size and amount.

With RCLs, the loss of non-repayments can be shared between taxpayers and the cohort of RCLs recipients, hence more financial support could be available to a larger population of firms. The cohort can pay either risk premium interest rates or higher loan surcharges, pushing the interest rates above the government cost of borrowing, which might lead to adverse selection. However, hybrids of different public support instruments could be adopted to seek to overcome those issues.

Although the involvement of ATO in collecting RCL debts minimises moral hazards, further improvement should also be considered. To mitigate potential moral hazard and adverse selection, and ensure functional RLCs, professional accountants and financial advisors should advise as well to consider all the ways where things could go wrong with administrative implementation of RCLs. But one key feature of RCLs is that revenue offers far less opportunity for reporting manipulation than profit-based loans.

The implications for the government revenue stream and subsidy are therefore quite profound in principle. But what is needed is some capacity to actually evaluate what this magnitude might be. This is what is discussed in the next section, and represents a major new contribution through this thesis' research.

Figure 3.10 Firm count by turnover (2019)



Source: ABS Counts of Australian Business 8165.0, Feb 2019

3.4 Data and methodology

3.4.1 Data

The main data source used for this research is the ABS confidential, balanced, panel Business Longitudinal Database (BLD) dataset which was collected for five financial years: 2006–07 to 2010–11. This data set comprises 15,375 observations for 3,075 Australian SMEs. The representative sample was chosen by ABS from total population of 1,259,953 firms, data that was collected via the annual ABS Business Characteristics Survey (BCS) and annual ATO BAS administrative data to allow longitudinal analysis. Each year a new panel is initiated of all 'economically active' firms with an active Australian Business Number (ABN), without new additions to the already existing sample. The sample consists of firms with less than 200 employees, as the focus of the BCS survey is on the market sector of the economy. The sample for each BLD panel is stratified by firm size and industry division (ANZSIC 2006).[28] Firm size is based on Derived Size Benchmark (DSB) which is a derived employment number using ATO data, which doesn't change over time, although firms change their size over time, leading to differences between true employment and DSB.

There are four firm sizes used in stratification:

- non-employing firms, such as sole proprietorships and partnerships
- firms with 0–4 employees
- firms with 5–19 employees
- firms with 20–199 employees.

[28] States are not included in the stratification.

After the stratification, approximately 40 firms per stratum were selected. After the expected death probabilities for each individual stratum were removed, approximately 30 firms were left which were still alive at the end of the five-year period. Those 30 live firms per stratum were considered viable for panel analysis.

More than half of the business units (almost 60%) included in the dataset have introduced some sort of innovation. The dataset provides information about two variables: firm size, firm age.

As the quality of the end results depends on the input data, its quality is of huge importance for microsimulation models. In reality, the data is imperfect. As noticed by many authors, for example Zaidi and Scott (2001), Cassells *et al.* (2006), Klevmarken *et al.* (2008), it is hard to find micro datasets with all the information needed to perform microsimulation models. The ABS dataset misses much valuable information for this research. That could be improved if different outside datasets could have been used, but working with ABS firm-level micro datasets didn't allow that. Further, the accuracy of different variables varies. Some, such as BAS indicators, can be very accurate, whereas many self-reporting indicators can be very subjective.

For evaluating the impact of the policies over longer periods, long panel datasets are needed. The ABS dataset is only five years long with no opportunity to merge with previous datasets, due to confidentiality and ethical concerns of working with ABS datasets. This caveat can, however, be somewhat overcome by using microsimulation analysis as a tool for generating synthetic microdata, and answering 'what-if' questions.

3.4.2 Methodology

To produce life-cycle revenues across Australian SMEs and simulate loan repayments, this analysis uses Conditional Quantile Regression (CQR) for the static model. A static life-cycle model of revenues is used to generate lifetime revenue projections across Australian firms which will serve as a basis for design of RCL and analysis of repayments. To analyse the effects of the RCLs on revenues, a pragmatic approach is needed to take into consideration not just he mean but different points along the distribution of revenues; quantile regression is used to model revenue at different quantiles. The structure of the model is based on Dearden (2019), with some modifications. A micro simulation study for government subsidies for profit contingent loans for business innovation in Australia was previously done by Denniss *et al.* (2009), but their simulations involved profit not revenues and they didn't use quantile regression for producing life-cycle revenues. Further, their study assumed a firm may borrow up to 50 per cent of their expenditure and no more than $5 million in total. They also used profit projections for only 3 business sizes.

To choose the most appropriate method for the dataset for our research, both Unconditional Quantile Regression (UQR) and CQR were initially used. The nature and comparison of CQR and UCQ follows.

1. Conditional Quantile Regression

First introduced by Koenker and Bassett (1978), as its name suggests, CQR is conditional on certain values of observed covariates when assessing the impact of a covariate or covariates on a percentile or quantile of the outcome, in this case revenues. Following Dearden's (2019) model for repayment burdens of student loans, this model's estimates are smoothed by age. Specifically, conditional on the observed covariate, age A, can be expressed as any function of A: $Q_{\tau}(Y|A) = \xi(A' \alpha_{\tau})$, meaning revenues change by age, where A is age, Y are revenues, τ is the conditional percentile or quantile, and α is the minimising sum of square residuals for the mean of revenues. In the case with CQR, analogously α_{τ} for the τth conditional quantiles are estimates with minimising sum of asymmetrically weighted absolute residuals (Koenker, 2005). The estimated coefficients ($\alpha\tau$) might be interpreted as marginal effects (as the covariate age is not a binary variable) on conditional quantile of revenues, conditioned on the mean values of other variables (Koenker and Hallock 2001). CQR assumes conditional effects vary across values of age, and hence are heterogenous. The intercept for the τth percentile represents the conditional distribution, with all other variables being 0.

2. Unconditional quantile regression

According to this method, unconditional expectation of revenues will change if the unconditional distribution of age changes. Various methods can be used to obtain a covariate effect on the unconditional quantile. As shown by Firpo *et al.* (2009), one first way is to start from the CQR estimates and then integrate out over conditional covariates to estimate the unconditional effects, though this is often practically intractable. To overcome the limitations of that model, they propose unconditional quantile regression based on a recentred influence function (RIF).

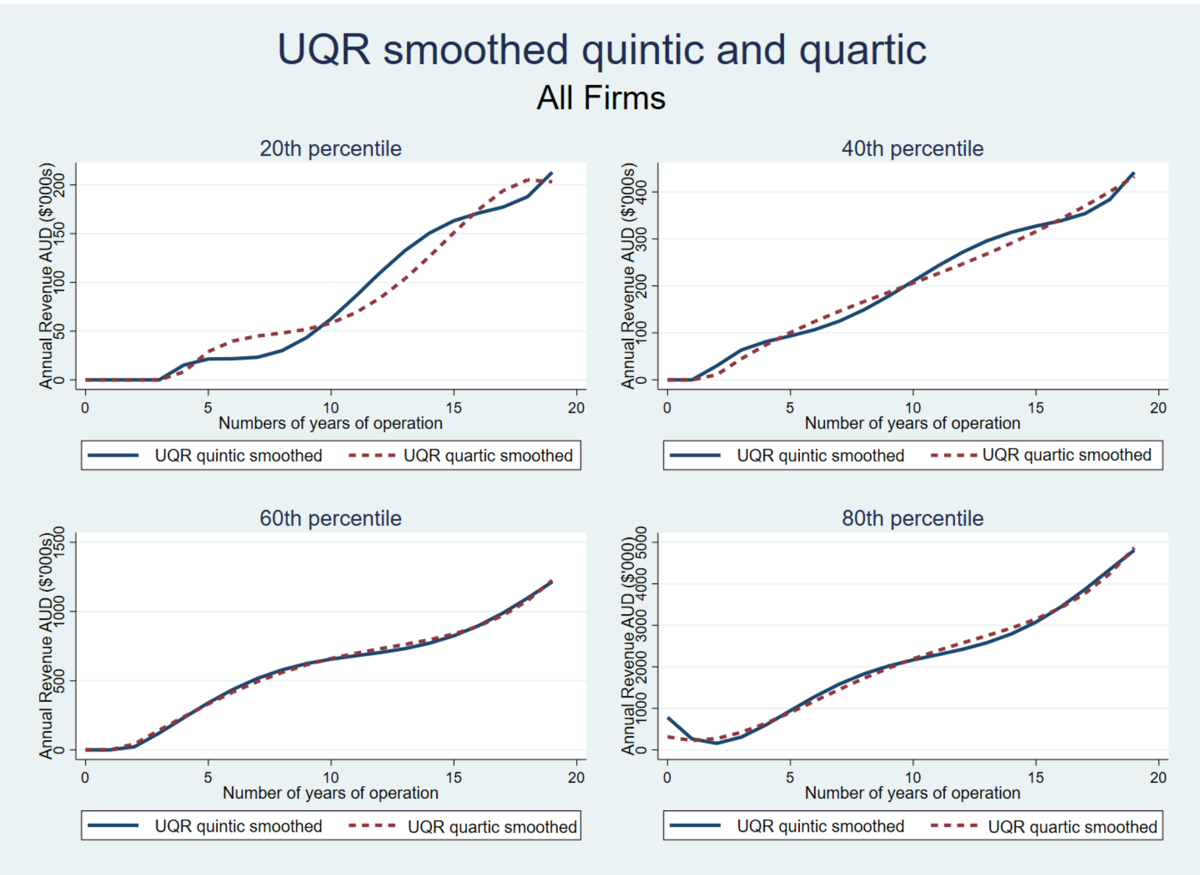
If qY(τ) presents the τth percentile of the unconditional distribution of Y, in this case revenues, then τ = FY(qY(τ)). According to Firpo *at al.* (2009), the first step for a specific percentile or quantile τ of Y is to estimate RIF. Then, using that estimate, the estimates for qτ have been got. After that, on the observed covariates, A (age), an ordinary least square regression model (OLS) regression is run of the RIFs (y;q τ). This RIF regression can be considered an UCQ, as unconditional quantile regression method is always evaluated marginally over the distribution of age, marginalising the effect. The covariate effects show the change of that covariate by one unit of analysis, while holding the full distribution of potential other variables constant. However, when the conditional effect does not depend on other covariate values, the conditional and unconditional effects on the percentiles/quantiles are identical for any percentile/quantile of revenues.

Until recently, this UQR model was the one most used in student-loan literature (Chapman and Lounkaew 2015; Chapman and Doris 2019). Some researchers have justified UQR over CQR as their interest was the effect of age on unconditional earnings (Chapman and Doris 2019).

Following Dearden's (2019) notion that CQR is a more appropriate and applicable method for simulating firm revenues, which will serve as a basis for design of RCL and analysis of repayments etc, UQR and CQR are compared now with smoothed raw quantiles by firm age and different functional forms. Comparison is further done between UQR and CQR for different firm sizes.

Figure 3.11 tests the flexibility of UCQ functional form in firm age to see if the estimates of the revenue quantiles at each age will be reasonable. Dearden (2019) found that UQR is very unstable and sensitive to the functional form with their data. UQR doesn't seem to be as sensitive to the functional form with this data, apart from instability shown for lower quantiles. For comparison, UQR smoothed with quintic and quartic polynomial in age were compared. Higher orders of polynomials were used to capture the possible drops in revenues and fluctuations in revenues. Quintic polynomial of age does fit the data better.

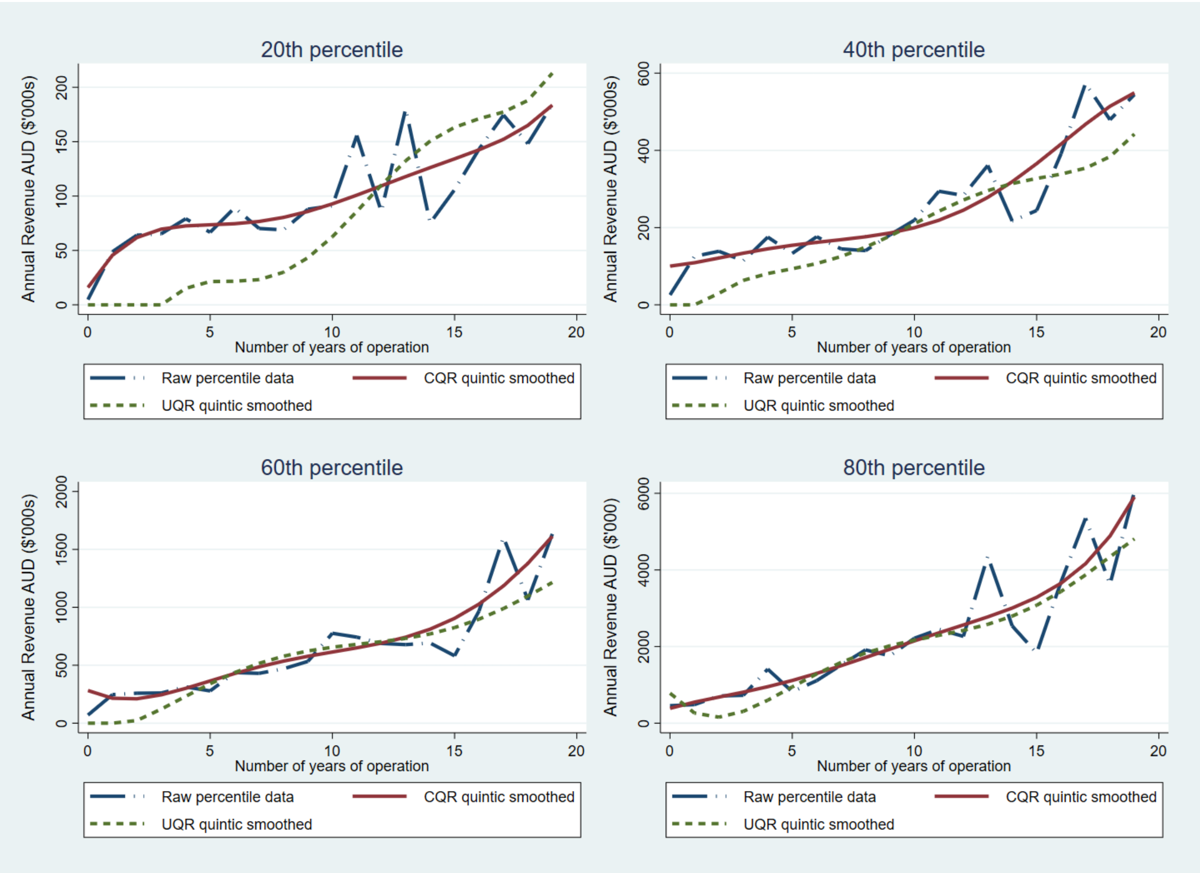
Figure 3.11 Flexibility of UCQ functional form



Source: ABS; Author's calculations

Figure 3.12 presents which method approximates the raw quantile data better by firm age, both UQR and CQR use smoothing raw quantiles using quintic polynomial in age. Estimates for both UQR and CQR are compared for all percentiles of all firms' (regardless of their size) revenue distribution using ABS BCS 2006-2011. As it is shown, CQR fits the raw quantile data[29] better than UQR, hence it shall be used further.

Figure 3.12 Comparing methods (raw percentile, UQR and CQR) for all firms: different percentiles



Source: ABS; Author's calculations

[29] Raw percentile data is linear prediction after a linear regression of the raw percentiles data on a quintic polynomial in age.

This process has been repeated for every percentile of Australian firms' revenues for different firm sizes.

3.5 Simulating firms' revenue distribution

A static life-cycle model of revenues is used to generate lifetime revenue projections across Australian firms using Conditional Quantile Regression and 2006–2011 data from the BCS. As revenue data is omitted from the model, total sales are used as a proxy. The revenue simulations involve the outcomes for firms with revenue from the lowest 10% to the top 10%. Descriptive statistic for total sales for the whole sample and for each firm size used are reported in Table 3.2.

Table 3.2 Descriptive statistics

	Observations	Mean	SD
Total sales (all firms)	11095	3596041	1.24e+07
Total sales (non employing firms)	2901	327827.2	1232598
Total sales (micro firms)	2894	1165453	6542901
Total sales (small firms)	2751	2967352	8200836
Total sales (medium firms)	2549	1.08e+07	2.18e+07

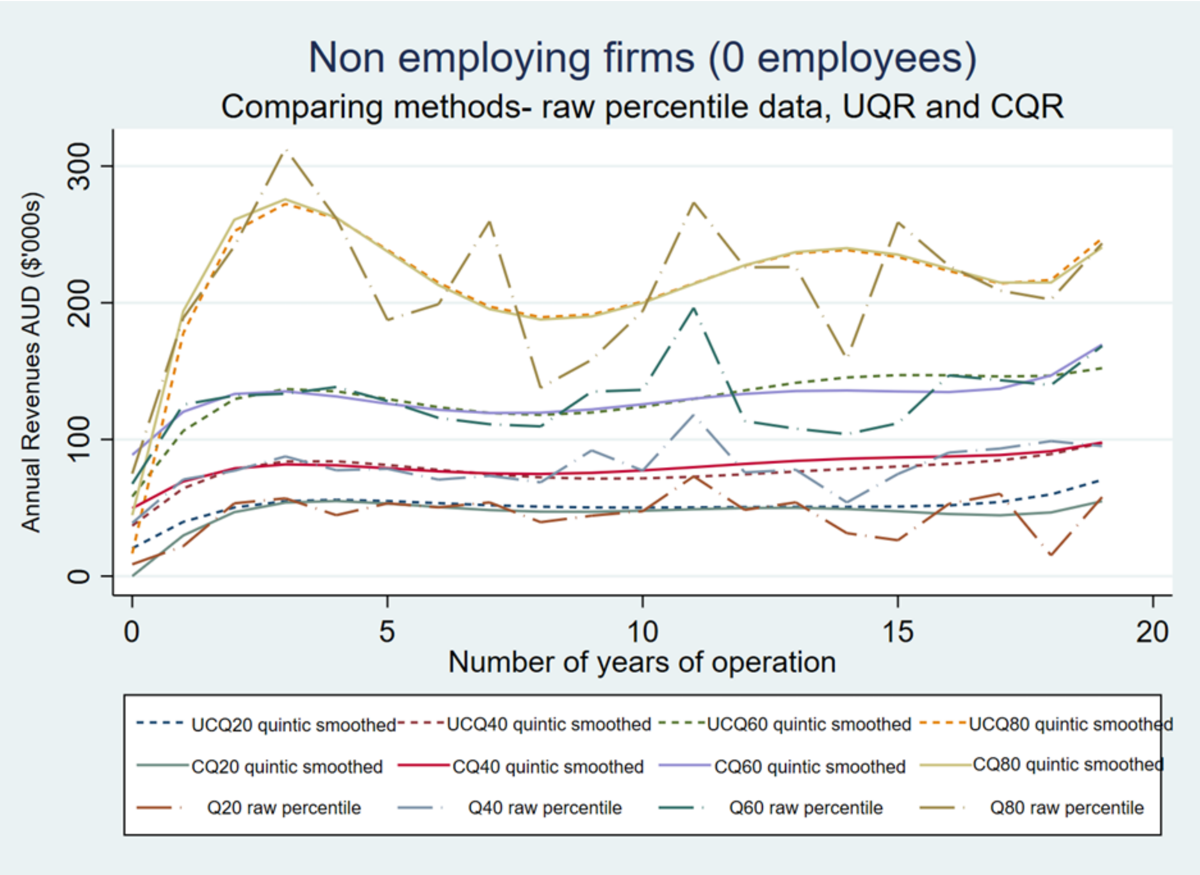
Source: ABS; Author's calculations

This model assumes that firms remain in the same part of firms' revenue distribution their whole life; for example, if a firm start in the lowest revenue quintile, it is assumed they remain there during their entire life. This is unlikely to be accurate for all firms since some firms during their lifetime will experience revenue losses and gains, but for the purpose of this exercise, to conduct the RCL analysis, the static revenue distribution is used.

The resulting simulated life-cycle revenue profiles for different types of firm sizes and quantiles of distribution are shown in Figures 3.13, 3.14, 3.15 and 3.16 for non-employing, micro, small and medium firms, respectively. A quintic specification performs best for all percentiles of the firm distribution. For each percentile, the estimates of parameters predict revenues at each operating year of firms from 0 to 20, providing an image of the entire distribution of life-cycle revenues. These are used as the basis for the analysis in the next sections of this essay.

Figure 3.13 shows the simulated life-cycle revenue profiles for different quantiles of the distribution for non-employing firms (firms which have 0 employees). The gross revenues of firms in Q20 and Q40 have been relatively stable over time, averaging less than $100,000. For those firms in the top 20%, the situation is somewhat different, with greater variability and averaging around $200,000.

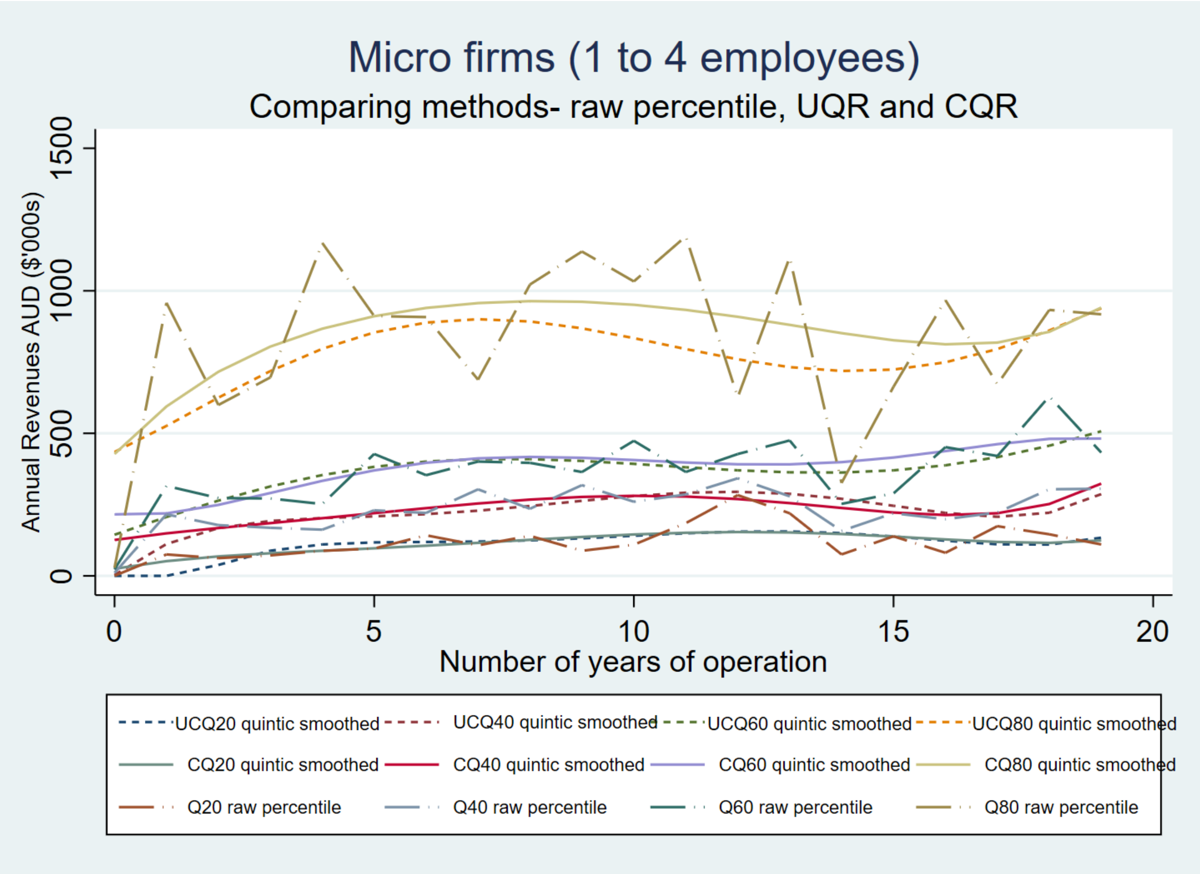
Figure 3.13 Revenue distribution for non-employing firms



Source: ABS; Author's calculations

Figure 3.14 shows the simulated annual revenues for micro sized firms (with one to four employees) for four quantiles, from bottom to top 20%. The CQR parameter estimates fit the raw percentile data the best for all quantiles, with only the highest 20% having annual revenues more than $500,000.

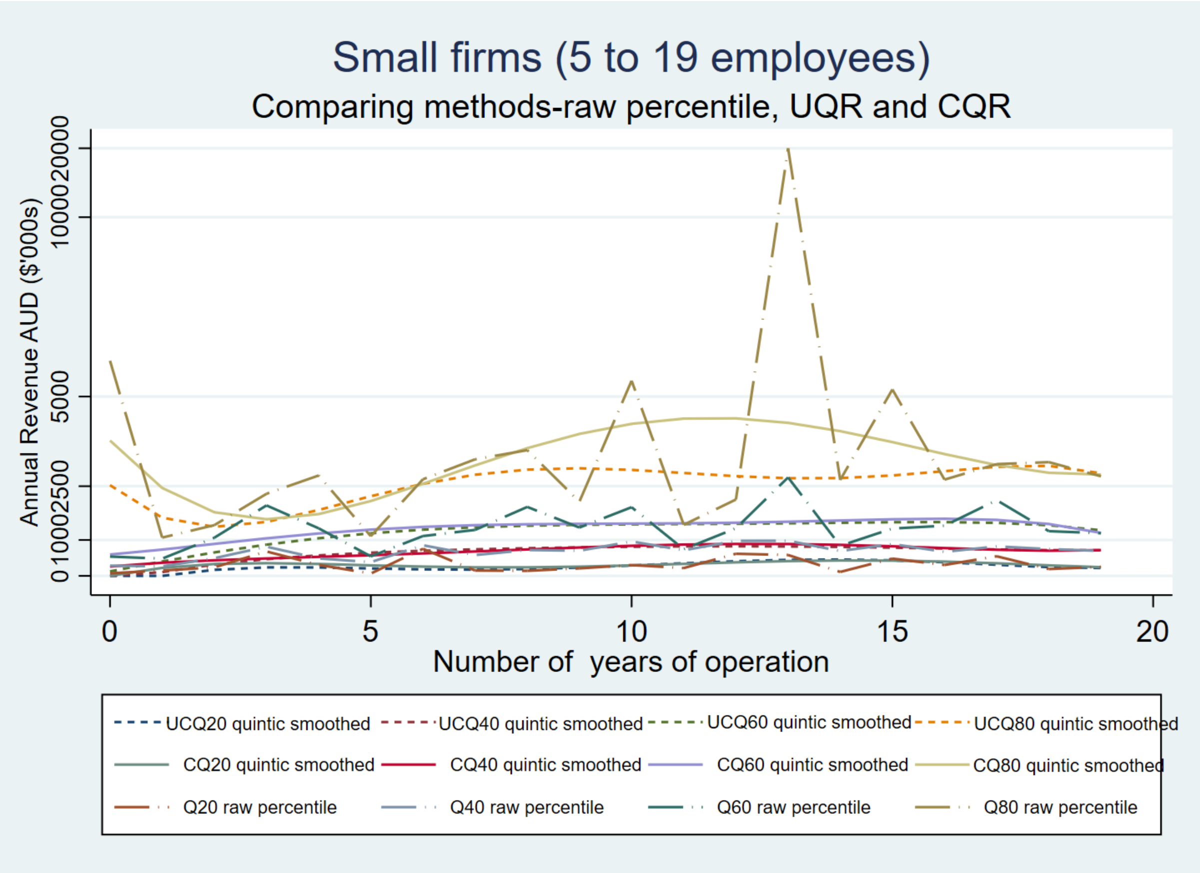
Figure 3.14 Revenue distribution for micro firms



Source: ABS; Author's calculations

Figure 3.15 shows the simulated annual revenues for small firms (with five to 19 employees) for different quantiles. As shown, most of the quantile profiles are around $1 million and only the highest quantiles exhibit bigger volatility in their earnings.

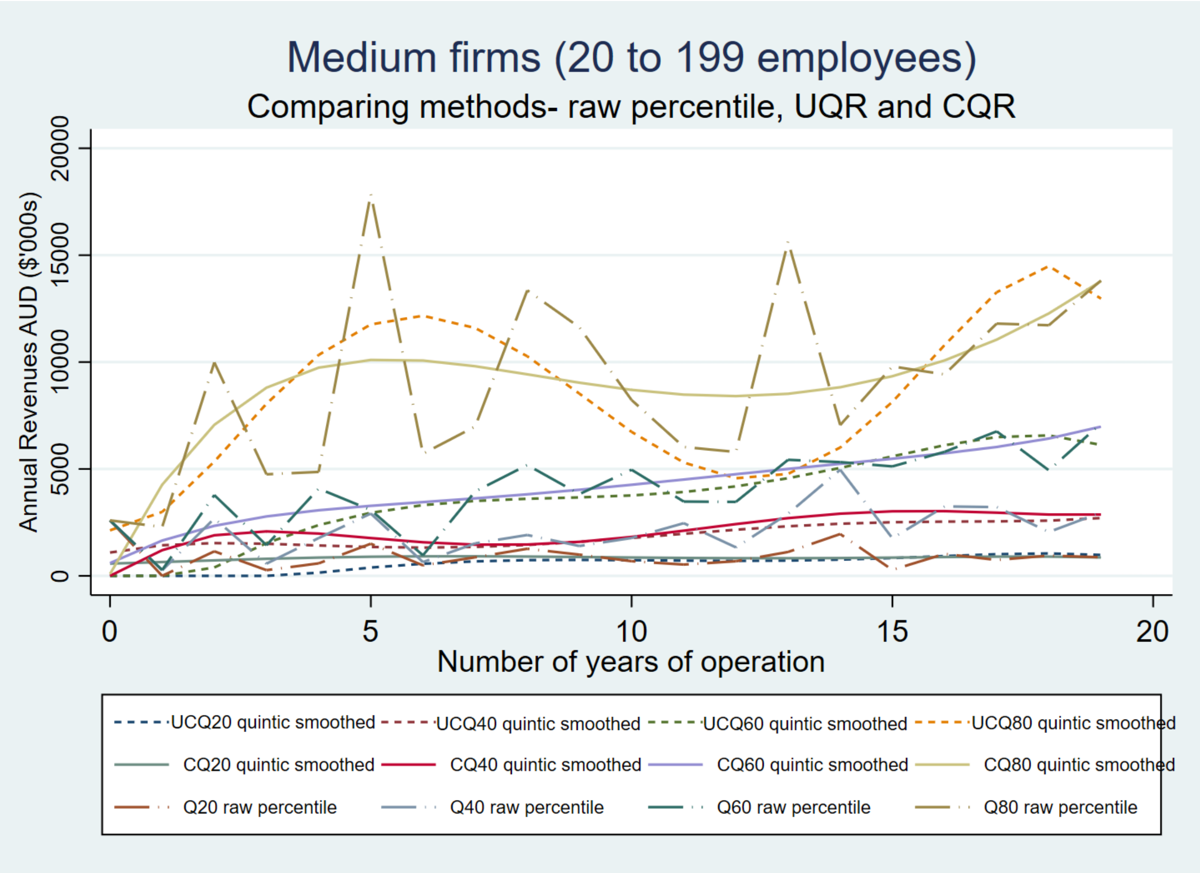
Figure 3.15 Revenue distribution for small firms



Source: ABS; Author's calculations

Figure 3.16 represents the distribution of simulated revenue profiles for medium firms (firms with 20 to 199 employees) for different quantiles. The picture here for highest quantiles shows great variability in their annual revenues.

Figure 3.16 Revenue distribution for medium firms



Source: ABS; Author's calculations

Three steps have been used for the simulation. In the first step, the distributions of life-cycle revenue profiles are simulated. In the second step, using the distribution from the first step, individual annual revenue profiles are simulated. Then different specific assumptions for the parameters are assumed and accordingly analysed in the next sections.

3.5.1 Detailed concept features of the RCL scheme

Once the quantiles of 20 years of firm revenues have been simulated, which serve as a basis for the analysis, certain parameters should be assumed. This section specifies the details of an RCL scheme to calculate government loan subsidies. The assumption is that all firms stay in the same quantile over their lifetime. While each firm's needs will differ due to many factors, for the simplicity of modelling, certain parameters are chosen. There is a large possibility of different alternatives and combination of parameters, which government can decide upon after taking into consideration the trade-off between desired subsidies and administrative costs.

The design of RCLs is crucial for the extent of taxpayer subsidy. If the aim is towards a 0 taxpayer subsidy, then different RCL design parameters can be adjusted accordingly (e.g. size of loan, real interest rate, loan surcharges, repayment thresholds, repayment rates and loan duration). As Barr *et al.* (2019) suggested, ICL design will depend on: the choice of parameters, different weights and their interaction; size of loan; the earnings modelling; the tax system and political sensitivity regarding the surcharges.

RCLs will not be secured, meaning collateral[30] will not be required and, as in the case of matching grants (which are a 100% cost from the government's perspective), the total sum can go up to 80% of the cost of the innovative project. If after their grace period[31] firms earn

[30] An asset (either a machine or property) serves as a security against the debt for the creditor who provides the loan in the case of non-repayment.
[31] The grace period is the period of time in which RCL repayments are not required, even if a firm earns above a certain threshold. It is the time from the date of receiving the funds to the first required repayment.

above a certain threshold or without threshold, the RCL sum will be repaid in those years with an interest rate[32] and, potentially, a risk premium and/or surcharge.

RCLs shall be available to all firms who fulfil a certain set of criteria for their business indicators and their innovation, and who wouldn't be funded otherwise on the private market, in order to avoid crowding out of public investments.

For the insurance-built element in RCL to work, RCL repayments should be made from current revenues rather from past-year revenues, as revenues can be unpredictable and changeable over time. The repayments from current revenues accurately represent a firm's financial power and, accordingly, ATO collects taxes monthly, quarterly or annually.[33] However, as revenues can be quite unstable, especially for young and small firms, and to deal with seasonal differences as well, RCLs require repayments to be made annually based on current revenues.

As repayments are done accordingly to individual business circumstances, risk of defaulting is lowered. Firms with higher revenues might repay their loan sooner than firms with lower revenues, adjusting the RCL to the individual circumstances. Voluntarily early repayments are allowed if a firm wishes, although this is not modelled.

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[32] Interest rate expressed as a percentage of the principal is the amount charged by the creditor (in this case, the government).

[33] ATO has certain rules when tax collection is taking place depending on a firm's turnover: monthly, if a firm's turnover is equal or more than $20 million; quarterly, if a firm's turnover is less than $20 million; and annually, if a firm's turnover is under $75,000 ($150,000 for not-for-profit bodies).

There is no maximum period of repayment, but it is applied with certain rules to minimise the moral hazard. RCLs would be attached to firm's ABN to ensure repayments, even with ownership changes. If the owner dies or the firm is sold without continuation in operation, repayment liability would be against the estate and the remaining balance on RCL would be paid in full. The survival rate of firms in Australia is 60% for small firms, so it is important to note that bankruptcies are a common occurrence, especially in innovative-active businesses.

According to the *Corporations Act 2001*, in case of insolvency, secured creditors[34] are given priority for repayments from the estate, then employees and, in the end, if anything is left, unsecured creditors[35] are repaid from the remaining estate. Government is an unsecured creditor by default unless stated in the RCL contract that the loan is secured. If the loan is secured, in future that will lower the borrowing capacity of the firm on the private lending market. Hence, the policy decisions will have to weigh different options and trade-offs between lowering the potential moral hazard with securing interest or enabling crowding in of the private market funds into the firms with choosing unsecured loans. That decision is for government policy makers and is thus out of the scope of this essay.

Among other factors, the following subsections discuss different scenario choices, which are a matter for policy decision: the grace period; repayment threshold, repayment rates and debt levels; interest rate charged; at what percentage of total taxable revenue repayments are set.

[34] A secured creditor is a creditor who holds a security, such as mortgage, when lending money.
[35] An unsecured creditor is someone who does not hold a security.

3.5.1.1 Grace period

The grace period is a potentially important feature which is missing in the current private lending market. In the analysis, the grace period for the RCL is set to be three years over which no repayments would be expected, and no interest is accrued on the RCL. Innovative firms in different industries might benefit from different grace periods, firms in information technology, for example, might need less time (around two years), while medicine science, pharmaceutical and aerospace firms might require longer grace periods, from five to 10 years, or more, because those firms need more time for basic R&D, as their research process is longer.

3.5.1.2 Repayment threshold and repayment rates and debt levels

There are good reasons why the design parameters of an RCL need to be different from those found in student ICL policies. A key distinction relates to the fact that, with respect to the ICLs of Australia, England and New Zealand, student loans are only collected on debtor's earning over a given amount per year, known as the first income threshold of repayment. But because annual average revenues differ very significantly between firms, there is no obvious way to set a minimum revenue threshold that could be applied fairly and practically (Botterill and Chapman, 2006).

This analysis follows Botterill and Chapman (2006)'s modelling of RCLs for drought and the Chapman and Lindenmayer (2019) simulations with respect to the use of RCLs for the financing of sustainable agricultural projects. Both exercises used a collection approach with no minimum threshold of repayment, applying instead constant proportions of annual revenue for collection of the RCL.

Importantly, annual revenue can be a crude measure of a firm's performance, so in order to avoid repayment hardships for firms, repayment proportions of annual revenue should be low. As guidance, Botterill and Chapman (2006) modelled 2% and 5% of annual revenues, while the simulations reported in Chapman and Lindenmayer (2019) used 3% and 6% collection rates. For the purposed of this analysis, three different repayments rates are used and the results compared (2%, 5% and 8%), noting that if high revenue firms want to repay sooner without penalties they should be allowed, but this has not been modelled. Following the Barr *et al.* (2019) finding that repayment flow will be stronger with total income instead of marginal income, the gross rate is chosen instead of marginal as the repayment rate.

In order to ensure that firms have the future capacity to repay RCLs, it is important that loans are limited depending on the revenue experience of each firm, as modelled in Chapman and Lindenmayer (2019). Loan collections are capped at different proportions (from 10% to 150%) of historical annual revenues in the past five financial years, to compare their effect.

3.5.1.3 Choice of interest rate

In the choice of the most appropriate interest rate, the government cost of borrowing and the private market's lending interest rate need to be considered. First, if the aim is to have very low taxpayer subsidies, then the interest rate should not be much less than the government cost of borrowing. If the interest rate is higher than the government cost of borrowing, then the higher revenue firms who decide to repay their loan quicker will have the total cost of their loan in present value terms less than firms in lower revenues quantiles who take longer to repay a given size of the RCLs. The government cost of borrowing has averaged 5.5% nominal,[36] based on 10-Year Government Bond Yield in Australia (Higgins and Sinning 2013).

If the aim is not to attract firms who would have been otherwise financially supported by the private lending market, as discussed in Essay 1 (Chapter 2), leading to crowding out of public investments, the interest rate should not be below the private market business lending interest rate. The Reserve Bank of Australia's lending interest rates for business vary from 4.3% to 8.0% for small business and 2.5% to 5.0% for large businesses. As this analysis is focusing on SMEs, the 5-year average of the interest rate for three years fixed-term lending for small businesses, which is 5.2%, has been used.[37]

As the interest rate at private lending markets set at 5.2% is just below the government cost of borrowing of 5.5% and government loans at a below-market interest rate are considered as grants, in accordance with AASB 120 standard Accounting for Government Grants and Disclosure of Government Assistance, in order to distinguish between RCLs and grants, one of the interest rates for this exercise is set at 5.5% nominal or 3.0% real interest rate. In this analysis, three different real interest rates are used for the RCL design. No interest rate, or 0% real interest rate, which is below the government cost of borrowing; 3% real interest rate,

[36] The real rate is around 3%.
[37] The author has calculated the average interest rate based on a 5-year average of interest rates, from January 2015 to December 2019.

which equals the government cost of borrowing; and 5% real interest rate, which is above the government cost of borrowing.

3.5.1.4 Choice of cohort risk premium interest rate or loan surcharge

Alongside a positive interest rate, or as an alternative option, there might be a cohort premium risk interest rate or a loan surcharge of x% of the loan amount. For example, with a 10% loan surcharge, if a firm borrows $10,000, the outstanding debt would be $11,000. The advantages of a surcharge are discussed in Essay 1 (Chapter 2). A disadvantage might be the adverse selection, in that some firms might be reluctant to take on the loan because of the existence of a loan surcharge. In this exercise, three scenarios are used, one without loan surcharge, a 5% surcharge and a 10% surcharge, to examine the implications.

3.6 Simulation Results

The results of the modelling are reported in this section, investigating the overall government subsidies associated with the repayment patterns of different RCL designs. Dearden's (2019) method using Australian firms' microdata was used to obtain the static age-revenue profiles by regressing the raw revenue percentiles by firm age on a quintic polynomial of firm age. Having obtained these estimates for the bottom 10 to top 10 quantiles, a relatively straightforward way of simulating forward was taken for a sample of firms from the BCS panel for each firm size (non-employing, micro, small and medium firms).

It is assumed that, depending on the firm size, probabilities of firm's death[38] each year for non-employing, micro, small and medium firms are 15.0%, 9.2%, 5.5% and 3.9% respectively. The assumption is there are no new entries each year, rather the same 10 firms in each quantile of each firm size are followed, making 100 firms from each firm size and 400 firms in total. As each firm size has its unique probability of death for firms in all quantiles, 10 firms are assigned in each quantile with different revenue projections due to the exit of some firms. As debt level are capped at a certain percentage of historical annual revenues, each firm will have a different loan size. Then those revenue projections for all firm sizes and quantiles are used to calculate the aggregate stream of repayments and determine government subsidies as a proportion of the loan for different RCL scenarios.

The distinctions between scenarios are given by different interest rate; different debt levels- different percentage of the firms' history of annual revenue; different repayment rate; different probability of firms' death and different grace periods.

3.6.1 Debt levels

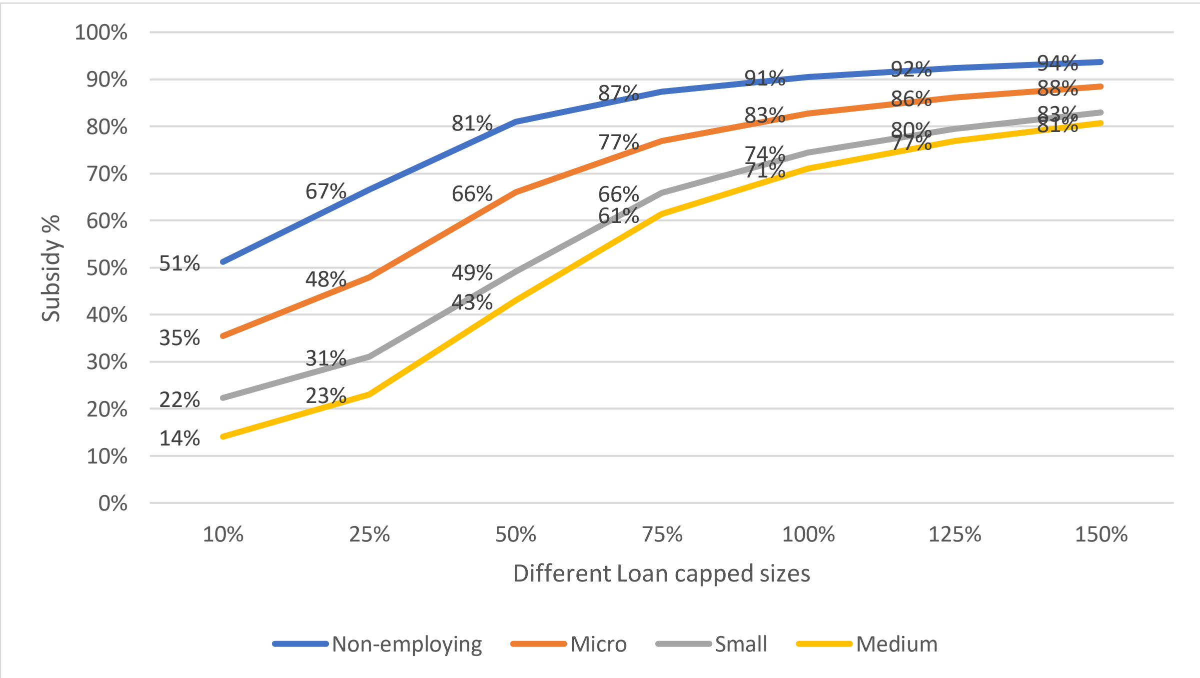
In this sub section, the results are presented assuming 3% real interest rate, 2% repayment rate, 1.1% discount rate and no loan surcharge. Figure 3.17 shows the government subsidy for different firm sizes and range of proportionate debt caps. Firms are provided with loans

[38] Probabilities are calculated as an average of exit rates for four financial years from June 2015 to June 2019 for firms by their employment size from the ABS 8165.0 *Counts of Australian Businesses*, including entries and exits, June 2015 to June 2019.

capped at different percentages from 10 percent to 150 percent of their average annual revenue for the past five years.

As expected, the government subsidy for non-employing firms are largest, starting at 51%, even with smallest debt levels capped at 10% of the annual revenues, due to the higher probability of death for those firms. In comparison, the government subsidy for medium firms is 14% for a loan size capped at 10%. The capacity for repayments lowers as the debt caps are larger. With loans capped at 100% of the average annual revenue, most firms will start defaulting, increasing the government subsidies from 61% for medium firms to 91% for non-employing firms. Loan sizes which are larger than average annual revenues will lead to defaulting and non-repayment of RCLs.

Figure 3.17 Government subsidy under different proportionate debt levels



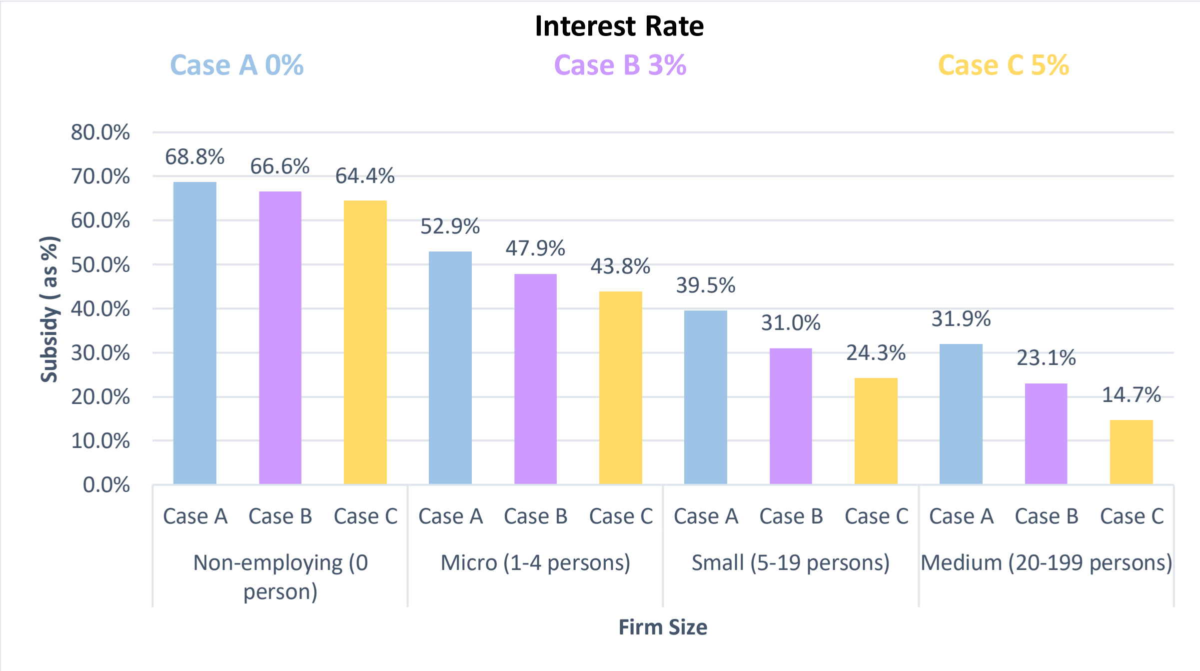
3.6.2 Interest rate

Figure 3.18 shows the relationship between real interest rate and extent of government subsidies for the RCLs described above for different firm sizes. Three real interest rates are applied to all firms regardless of their revenues and firm size: 0% (Case A), 3%[39] (Case B) and 5% (Case C) real interest rate. Other parameters are constant with proportionate loan size capped at 25% of average annual revenues in the past five years; 2% repayment rate; 1.1% discount rate and no loan surcharge.

Although theoretically any interest rate below the government cost of borrowing leads to subsidy, and any interest rate above leads to profit if most of the firms repay their debt in full, owing to the probability of firm's death and defaulting, the cost of unpaid RCLs may exceed the 'profit' from higher interest rate, resulting in subsidy. From the graph it can be seen that government subsidies for all firm sizes increase as the real interest rate decreases. For example, taxpayers subsidy for non-employing firms with 0 real interest rate is 68.8% and falls to 64.4% with 5% real interest rate. The choice of interest rate has less effect on non-employing firms than on medium firms where the fall in subsidy is more drastic, from 31% to 15% in subsidy.

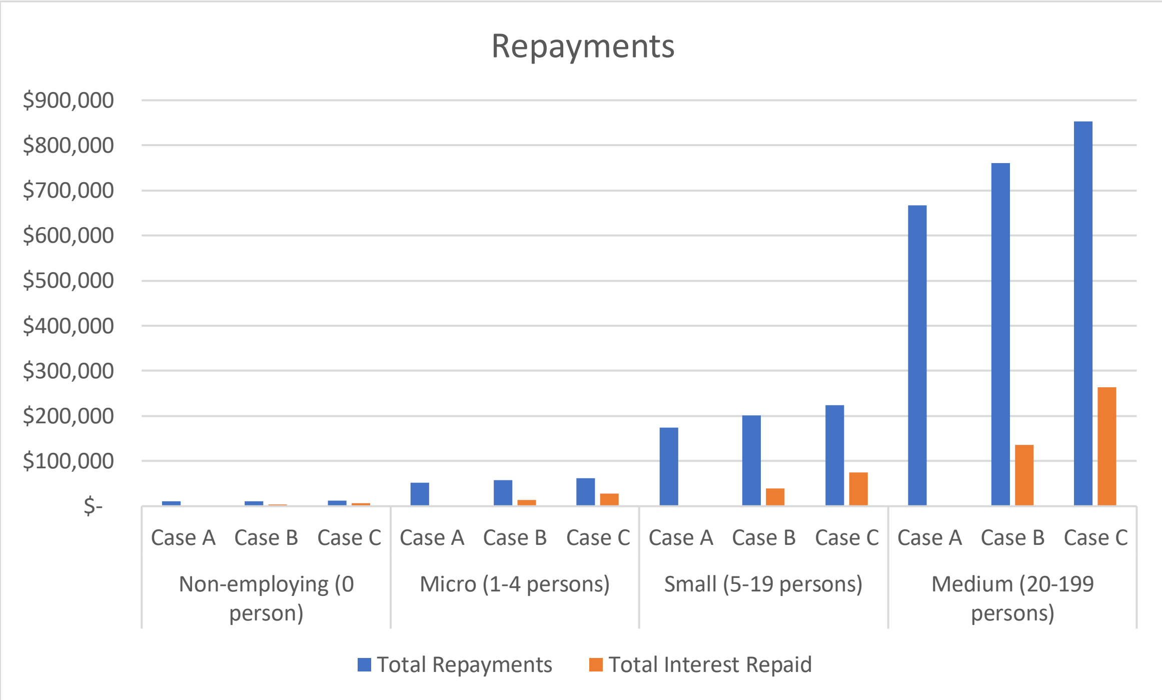
[39] Which is equal to the government cost of borrowing.

Figure 3.18 Government loan subsidy as a percentage, proportionate dollar loan caps 25%, 2% repayment rate, no loan surcharge



It is clear from both Figure 3.18 and Figure 3.19 that the larger the firm, the relatively more they repay, and subsidies respectively fall. Figure 3.19 shows the absolute value of repayments for all firms with the same parameters as in Figure 3.18.

Figure 3.19 Total and interest repayments (absolute values) under different interest rates

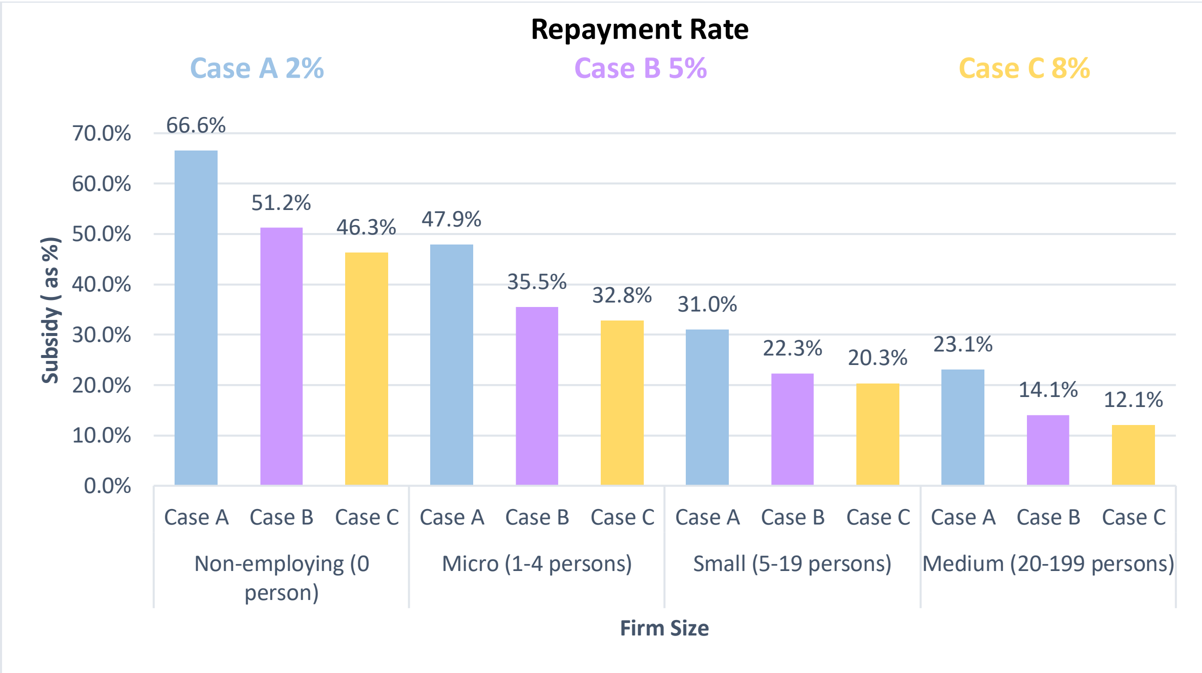


3.6.3 Repayment rate

In this subsection, the implications of imposing a repayment rate are considered. There is no repayment threshold at which firms start making repayments. Rather, after the grace period, they repay a certain proportion of their total revenues (the repayment rate).

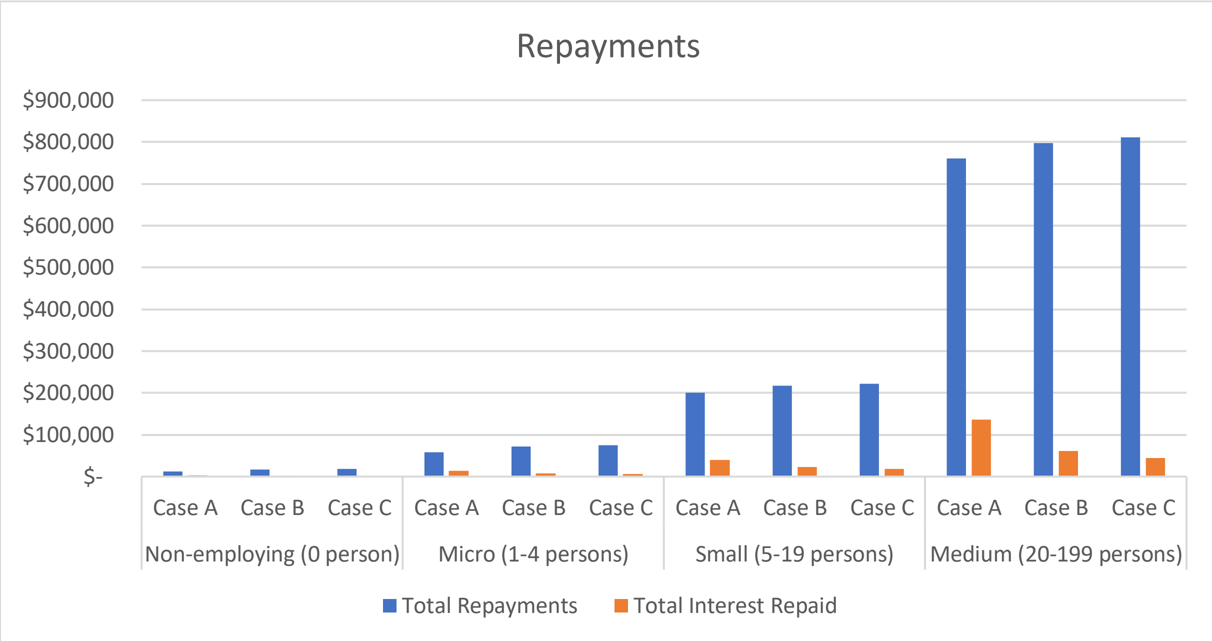
As can be seen from the Figures 3.20 and 3.21 below, the effects of increasing the repayment rate are similar to the effects of increasing the interest rate. Increasing the repayment rate along all firm sizes has a decreasing impact on the subsidies. The impact is largest among non-employing firms, with subsidies falling from 66% with 2% repayment rate to 46% with 8% repayment rate.

Figure 3.20 Government subsidy under 2%, 5% and 8% repayment rates



The amount of repayments increases with firm size. A problem that might arise with no threshold and repayment rate on total revenues is potentially making some firms worse-off as their ongoing costs are not taken into consideration, putting a financial pressure on them.

Figure 3.21 Total and interest repayments (absolute values) under different repayment rates

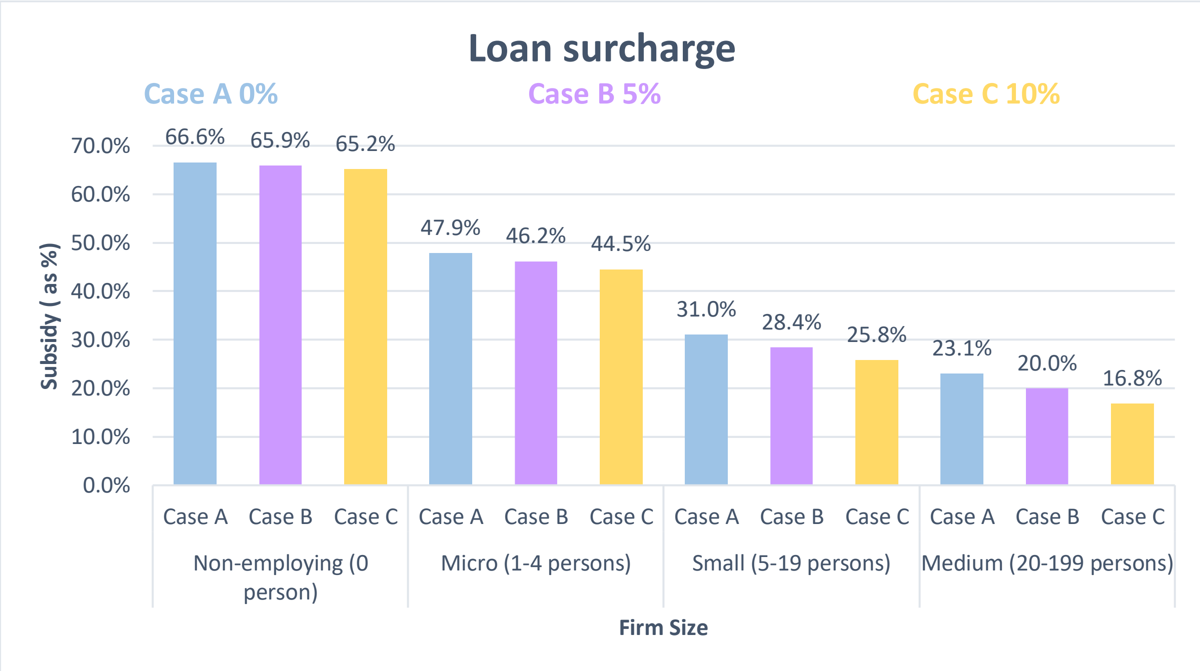


3.6.4 Loan surcharge

Another potentially important factor in determining the total government subsidies is the loan surcharge.[40] For the purposes of this exercise, the parameters of the RCLs remain the same as: 3% real interest rate, 2% repayment rate, 25% proportion of average annual revenues, 1.1% discount rate and appropriate probabilities of death for the firms. Three scenarios are compared: no loan surcharge, and loan surcharges of 5% and 10%. Figure 3.22 shows the implications of different loan surcharge options. It appears it doesn't have as huge an impact on subsidies as previously seen with the interest and repayment rates. The larger the loan surcharge the smaller the subsidy through all firm sizes.

[40] Which simply increases the total borrowed amount by a certain fixed proportion.

Figure 3.22 Government subsidy under 0%, 5% and 10% loan surcharge

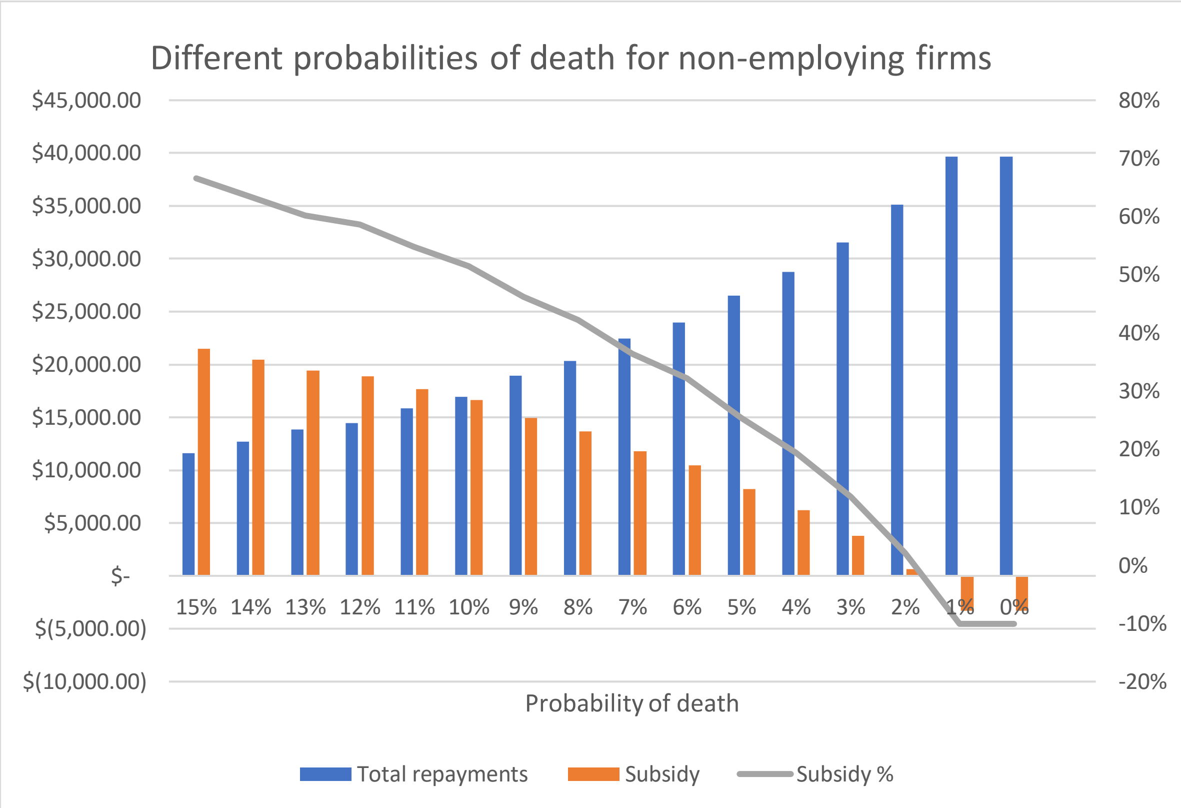


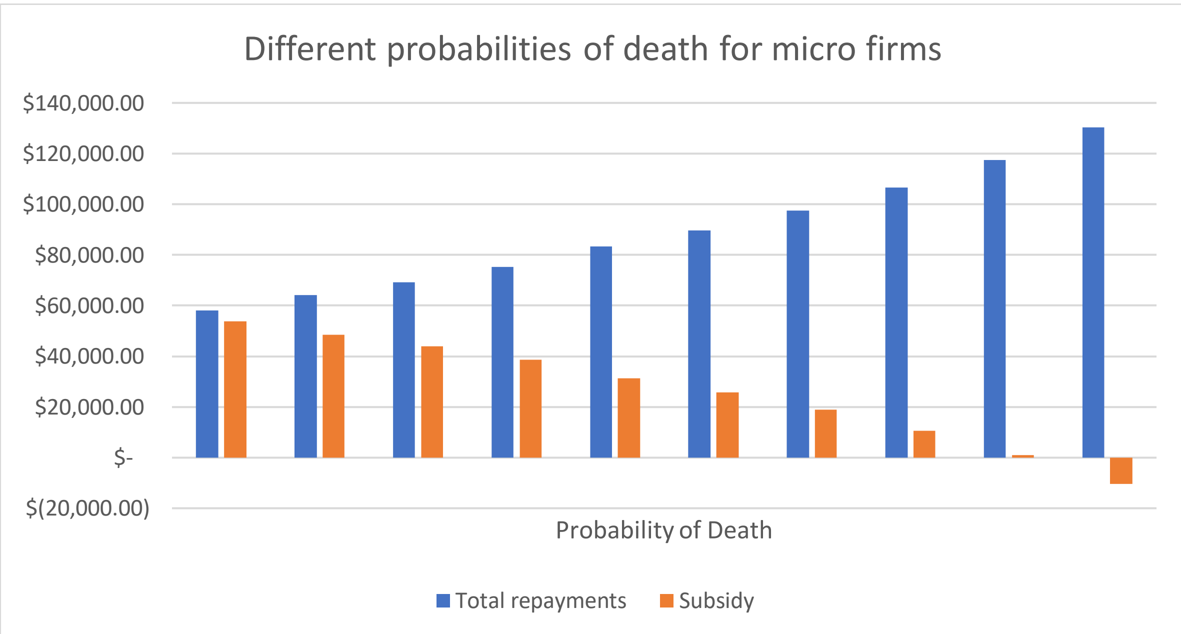
3.6.5 Probability of death

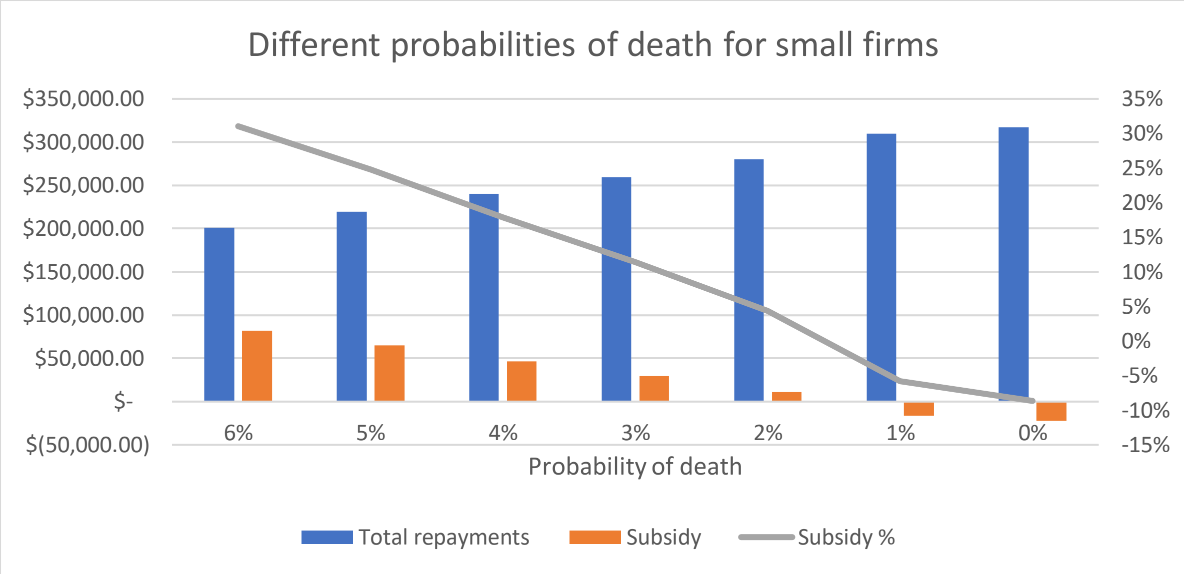
In the previous examples the implications of changing different RCL parameters were shown. As highlighted earlier, it appears that the subsidies are larger for smaller firms, due to the higher death probabilities for smaller firms. Figures 3.23 illustrate what would have happened to the total repayments and government subsidies if probabilities of death tend towards 0. Parameters used for this exercise are 3% real interest rate, 2% repayment rate, 25% proportion of average annual revenues, 1.1% discount rate, no loan surcharge.

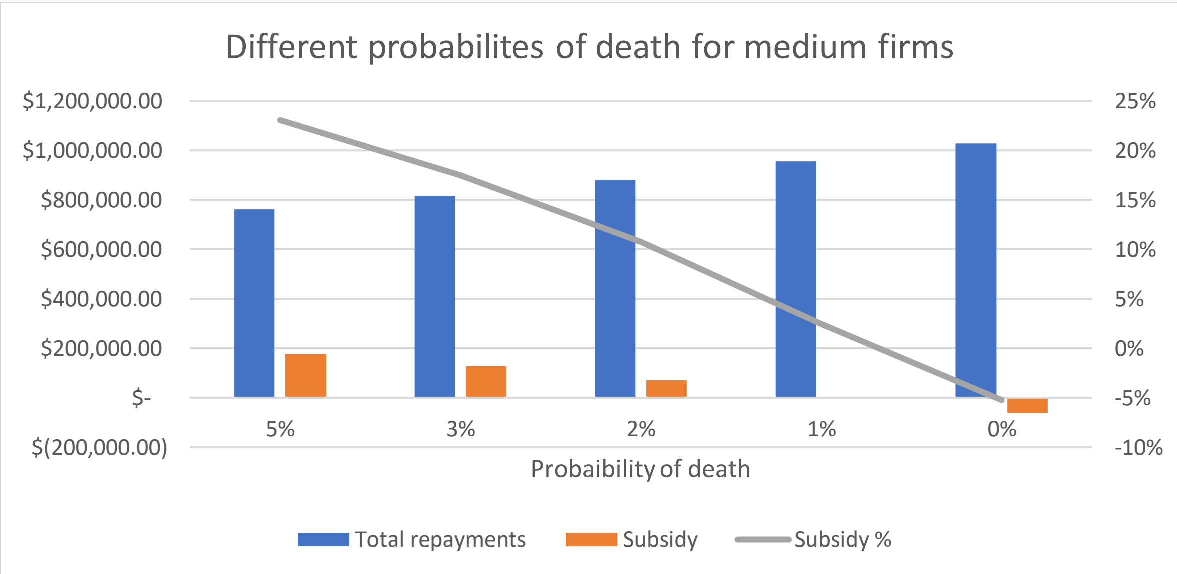
Figures 3.23 below show that when probability of death from firms is moving towards zero, the total repayments (in absolute values) increase while subsidies decrease with actually making profits when there is no firm exit.

Figure 3.23 Different probabilities of death for different firm sizes







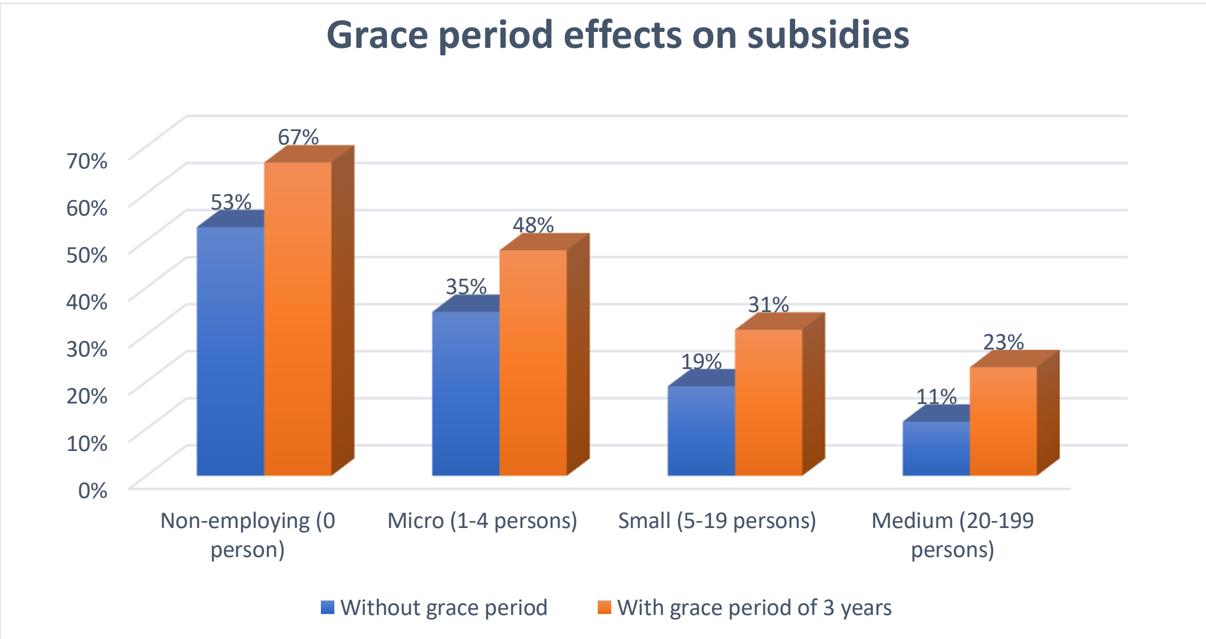


3.6.6 Grace period

This analysis further explores the consequences for government subsidies of different parameters, such as the grace period. For example, an issue of interest is the extent of subsidies related to the grace period, which could be reduced or eliminated. Such an approach is suggested and modelled in Botterill, Chapman and Kelly (2017). Figure 3.24 illustrates government subsidies if RCL repayments were without any grace period. As with previous baseline illustrations the parameters used for this exercise are 3% real interest rate, 2% repayment rate, 25% proportion of average annual revenues, 1.1% discount rate, and no loan surcharge.

As can be seen below from Figure 3.24, elimination of the 3-year grace period would result in lower government subsidies for all firm sizes. Government subsidies for non-employing firms with a 3-year grace period will fall from 67% to 53%; for micro firms, subsidies will decrease from 48% to 35%; for small firms, from 31% to 19%; and for medium firms, government subsidies will be decrease from 23% to 11%. The main reason behind the lower government subsidies with the elimination of the grace period, is that there is then the possibility of some RCL collection for firms unlikely to survive more than a few years.

Figure 3.24 Grace period effects on government loan subsidy as a percentage, proportionate dollar loan caps 25%, 3% interest rate, 2% repayment rate, no loan surcharge



3.6.7 Key summary of the main findings

The analysis of different parameters of RCL design on government subsidies shows that the government subsidies will increase from 50% to 94% for non-employing firms and 14% to 84% for medium firms, when the debt levels are increased from 10% of historical revenues to 150% of historical revenues. Hence, when allowed to borrow more than their annual average revenues, most of the firms, will default.

Interest rate differences tend to have a larger effect on government subsidies as firm size increases, there being only a few per cent decrease in government subsidies for non-employing firms to almost 50% decrease in government subsidies for medium firms when the interest rate increases from 0% to 5%. That is, the larger the firm, the larger the repayment value when interest rate increases.

The repayment rate has a similar effect as interest rates on government subsidies: an increase from 2% to 8% lowers the government subsidies for all firm sizes. However, unlike with respect to interest rates, savings in government subsidies are highest for non-employing firms, which might be related to their death rates being highest as well, so a higher repayment rate will ensure sooner repayment of the loan. Most of the savings are achieved with the increase from 2% to 5%, the savings with the increase from 5% to 8% repayment rate, are not as large.

Adding a risk premium or loan surcharge of 5% and 10 % to the loan amount does not decrease the government savings hugely, only few per cent decrease in government savings and savings and these tend to be larger as firm size increases.

Most of the differences in effects of different parameters on firms depending on their size are due to the different death rates for firm sizes. As the probability of death for firms decrease, total repayments increase, and government subsidies decrease. This promotes for discussion the potential role of eligibility for RCL being made contingent in part on the expected longevity of firms' lives.

The elimination of the 3-year grace period would result in lower government subsidies for all firm sizes. Again, this can be traced to the critical role of firm longevity.

3.7 Discussion

Even with relatively high interest rates for RCLs for business innovations, there are still subsidies for the RCLs. Two points should be made in response to that. First, Australian innovation policy for financing business innovation has always entailed subsidies as financial assistance has been in the form of grants (which are a 100% subsidy). In contrast, RCLs design entails significant reductions in subsidies, and could be made to lean towards a zero subsidy. Second, if the aim is zero subsidy, RCLs scheme can be designed with a cohort premium risk rate or loan surcharge (as explained in Essay 1).

The merit of RCLs is their insurance function against unsuccessful business innovation market outcomes. Hence, for firms, a universal application of it might be desirable.

It is important to note that different types of firms, depending on the area and industry, have different financial needs at different points in times. That heightens the need for tailored contingent loans for firms. Some might even argue that firms' success terms cannot be generalised, rather that the decision should be made on an individual basis. As firms start acquiring revenues after their breakeven point, it is crucial that the grace period be adjusted because, if a loan is repaid from their revenues before that point, the risk for the particular firm to end up in the 'valley of death' is enormous.

Breakeven point might not be the only success term which can serve as a starting point for repayments. Others might be commercial success, either through projected revenues, or the product being brought to the market, or have demonstrated innovation efforts to help ensure success for the innovative project.

Contingent loans might be very appealing to young firms with innovations in an early stage, as their innovative projects are followed by a relatively high degree of uncertainty. Hence, these young start-ups might have a higher preference for RCLs, where the repayment is contingent on project success and future revenues.

There still might be practical issues in delivery of RCLs as an innovative finance public instrument with a contingent repayment feature. Those issues arise from the possibility of the private sector finding ways to avoid repayments, questioning the feasibility for a government agency to track metrics such as those identified above.

Future studies need to gather more information about possible benefits of the RCL through cost–benefit analysis, which is beyond the scope of this essay.

3.8 Conclusion

In Australia, government continues to provide financial assistance to innovative businesses. A critical question that arises of public policy concern is whether some identified weaknesses in the present arrangements might be overcome by examining the implications of different forms of financial assistance. To this end, discussions on how to design public financial support to reduce problems of access to private finance and reach more firms than with the current grant scheme are encouraged.

An innovation of this essay is that it has examined the potential for an RCL for government intervention in the financing of business innovation, as an extension of the ideas behind existing ICLs for student loans. RCL would be a new policy scheme for Australia that includes measures to reform the direct public financial incentives system to become system oriented to reaching out to more firms than at present at no greater net cost to the taxpayer. RCLs provide insurance against default for all firms, in which repayments depend on a firm's revenues. RCLs currently might be considered then as a measure with potential for assisting innovation in the business sector, while not placing the same sort of burdens on taxpayers, as is the case with grant scheme.

In this essay the impact of RCL model parameters on government loan subsidies has been demonstrated. The results show the subsidies for government and revenue smoothing aspects of hypothetical, yet plausible, RCLs where firms have insurance against future adverse periods for revenues. RCLs also can be combined with other existing financial instruments, filling in the gaps in insufficient financing and alongside policy for other needs such as training and networks.

This essay has situated a proposal for RCLs for government financial support for innovative-active firms in the economic literature for both government intervention due to financial market failures in financing business innovations and government as a risk manager.

The findings of the study should be taken as an illustration of the likely subsidy implications of an RCL approach to innovation policy; there remain important limitation of the modelling – it is static. Further research should incorporate dynamic simulation and more sophisticated modelling.

The evidence in this essay is intended to be helpful to policymakers who might be interested in broad consideration of a suite of potential innovation instruments. It is critical that more detail is pursued regarding the most appropriate RCL design, taking into consideration the policy goals and trade-offs. In depth dynamic modelling is a key aspect of further policy development.

Although not covered in this chapter, other scheme details that require consideration before implementation, and could be explored in future work, include placing conditions on use of the loans, cases for and against provision of matching funds, etc.

In looking more closely at the possible adoption of an RCL approach to encouraging business innovation, the precise effectiveness of alternative policy must be part of a proper evaluation analysis. RCL is prospective and has been examined in this present chapter through simulation of its potential. The grant alternative is extant policy, however. Its pay-off can be directly estimated, to allow some comparative assessment of potential and actual to be made. The next chapter considers econometrically the effects of grants on innovation activity.

Chapter 4 An impact evaluation of direct public financial support for business innovation activities in Australia

4.1 Introduction

Innovation policy has acquired a central role among policy makers, with economic theory and empirical studies pointing to such innovation as one of the key drivers of economic growth, making firms more competitive through increasing their productivity and the quality of good and services (Schumpeter 1939; Bartel *et al*. 2007; Griffith *et al*. 2006; Hall *et al*. 2009; Halpern *et al*. 2012; Palangkaraya *et al*. 2015; Raymond *et al*. 2010). 'Innovation is widely considered as the life blood of corporate survival and growth' (Zahra *et al.* 1994) [41].

Due to many market failures and other constraints on innovators, as discussed in detail in Essay 1 (Chapter 2), governments have thought of many different ways to support innovative activity, especially through the lens of whole national innovation systems. Here again the focus is on public financial support for innovation in Australia. Due to the importance of the innovations, impact evaluation of such public support of innovations is on the rise as well (Edler *et al*. 2012). Public financial support for innovation has taken many different approaches over the last 30 years from indirect (as in R&D tax incentives) to direct fiscal incentives and grants, as discussed in Section 3 of this chapter.

This essay reports estimates of the effects of direct public financial support (grants) for innovative businesses in Australia, with the question being whether, and how much, firms increase their innovation efforts in response to government policy incentives. This is

[41] see Essay 1 of this thesis for a definition of innovation.

important for affirming the positive impact of public support on business innovation. The issue then becomes: what might be the cost of such impact under alternative instruments?

The preceding chapter looked at cost under a new instrument, the revenue-contingent loan (RCL). This chapter looks at the impact of government support through direct grants and draws on the actual experience of operation of such support. The effects examined in the previous chapter concerned hypothetical RCLs, and thus used simulation. However, with respect to the effects of grants, direct estimation can be pursued as the outlays are clearly known. Hence this chapter's contribution.

The rationale for public support for innovation is well established in economic theory. Market failures in the innovation field are seen as the key reason why innovations are more difficult to finance (Levin *et al*. 1987; Mansfield *et al*. 1981; Martin and Scott 2001; Hall and Lerner 2010), as discussed in more details in Essay 1 (Chapter 2). However, it is helpful in an essay-based format, to recap some of the key points.

Knowledge is embedded in innovations, and due to its public-good attributes, positive externalities/spillover effects are argued to be present in the literature. This makes the innovator's private returns smaller than the social returns, implying that without government intervention there would be a less-than-optimal level of investment in innovation (Arrow 1962).

Further, underinvestment in innovation might also be due to public-good attributes of innovation; innovators might have more information, but might not reveal the information to the private financial market. Underinvestment also occurs because innovations are followed by uncertainty.

Financial market failures are not the only rationale for government involvement: the institutional and coordination failures between actors and institutions of the innovation system are another reason for underinvestment and why government may intervene.

Government has the power to set up an institutional framework and underlying infrastructure to support innovation, and make sure all parts of the system are functioning well. Firms do not function independently, but rather interact between each other and other institutions in a 'system of innovation' framework (Lundvall 1992; Rossi 2002). As such innovations generate a complex system, access to finance is not the only barrier firms experience, as discussed in more detail in Essay 2 (Chapter 3).

Government can intervene with educational training to improve firms' innovativeness, as new firms may lack business and financial skills and appropriate technology (Hauknes *et al.* 1999). However, for the purpose of this essay, the focus is on direct financial support through grants to innovative firms.

The idea of government involvement is not to replace private markets for financing innovation but is rather to give an initial financial injection at the stage when private markets are unwilling to do so, that will later attract additional private sector investments.

Public funds for innovation might have certain pitfalls: non-innovative activities might be presented as innovative to get access to funds; government agencies might not have the necessary knowledge to award grants to the potentially best innovative firms; funds are provided for those firms are notable to generate highest positive externalities (Andrews *et al*. 2013).

To the best of the author's knowledge, this is the first paper to address the issue of the treatment effect of public financial grants on total innovative activities of firms across all sectors in Australia. This aspect then is the first research question set for this chapter. Most of the studies so far have focused on R&D activities and expenditures instead of innovation activities, perhaps due to the lack of data and appropriate measurements (Hall and Lerner 2010). The distinction between R&D and innovation is important.[42]

As one of the ideas behind the public interventions is 'additionality', this essay also explores the effects of the public intervention on the firm's internal changes in their innovative behaviour; for instance, if they innovated some process of production, marketing or organisation, if their knowledge of external sources is expanded, and/or if they improved their business and financial skills. These internal dynamics of firms are quite important in developing a new product, which is the materialised output of the investments in innovations, which can be considered as the most important capability of the firms (Nelson 1991). What the effects are of the public intervention of the innovation output (products) is the second research question examined in this chapter.

Rather than focusing only on the materialised innovation output, this essay also observes and evaluates the impact of the public financial support on the economic performance of the firms, as without increased productivity and competitiveness at firm level there wouldn't be any economic growth, which is the last element of the innovation output additionality. That is the third research question examined in this chapter.

[42] As stated by the OECD (2005), 'Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of humankind, culture and society—and to devise new applications of available knowledge. Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.'.

In addressing these questions, this research builds upon a previous core model for examining the relationship between a firm's investments, innovation output and productivity, as proposed by Crepon *et al*. (1998) and Hall *et al*. (2008), using an ordinary least square regression model (OLS), fixed effect method and propensity-score matching. Section 4 of this essay (Chapter 4) discusses their model in greater detail.

This study makes three contributions. First, it provides new results and insights into the effect of public grants on business performance of innovative firms. Second, it has an advantage over existing empirical studies for evaluating public financial instruments for business innovations as it provides new insights across different industry sectors. The empirical literature has focused mostly on manufacturing sectors, and nowadays other sectors in developed economies have a bigger share in GDP, hence this essay contributes to the literature by reporting analysis of the impact of public direct financial programs across different sectors.

Third, this is one of the very few studies that have examined public financing for innovations for Australia, and the only one that has examined public grants for innovations for Australia. There is considerable evidence of this kind of study for European and Latin American countries.[43] However, to the author's knowledge, this is not the case with Australia, where, so far, there has not been a broad quantitative study of evaluating the public support financial instruments for innovative firms. However, two sets of studies closely related to this topic have been undertaken for Australia. One set is a panel regression analysis by Reversz & Lattimore (2001) of the impact of program participation on a firm's performance. However, the effectiveness of the program was not evaluated, and there was no counterfactual. The

[43] For reference, please see Table 21 in the Appendix.

other set is Thomson (2010) and Thomson and Skali (2016) on the effectiveness and the rate of additionality of R&D tax subsidies in Australia, with a significant positive impact being found. [44]

The remainder of this essay is organised as follows. Section 2 provides a recap and focusing of critical literature on theoretical research for innovation financing rationales. It then looks at empirical research of the effects of public financial instruments on business innovations, highlighting knowledge gaps that this study hopes to fill. Section 3 provides an overview of innovation policy in Australia to position the grant support very directly. Section 4 describes the econometric models and rationale for variables used in this study to assess grant impact. Section 5 describes the dataset used to allow the estimation. Section 6 presents the estimation results and compares and contrast them with existing evidence. Section 7 concludes and suggests policy changes and further research.

4.2 Literature review of public financial support for innovation

There is an extensive literature on why private markets fail to invest in innovation at the optimal level. The three main reasons for those market failures are: public good and externality characteristics of knowledge creation mean that social returns can be higher than the private returns on innovations; knowledge as an intangible asset exacerbates even further the divergence of social and private return because of asymmetrical information and moral

[44] Other studies have used the same dataset (see Jensen and Webster (2008) and Palangkaraya *et al.* (2015)), but were looking at which factors increase the firm's innovation rather than being interested in seeing the effects of government grants on innovation.

hazard problem, which leads to private underinvestment in innovations; innovations are especially highly uncertain and risky endeavours, as explained in detail in Essay 1 (Chapter 2).

Apart from these market failures, evolutionary scholars believe that public support for innovation shall exist also because of the national innovation ecosystem. For the purposes of this chapter, the focus will be on the stated market failures reasons, predominantly arising from the public-good character of the knowledge.

Governments all around the world have focused on increasing the level of R&D investment generally. However, rather than focusing only on increasing the R&D expenditure and treating the firm as a black box, the focus here is also on a firm's productivity and performance, and long-term improvements.

The wrong focus can indeed motivate firms to lower their own autonomous R&D investments for the amount that they can get from the government, hence not adding to the total R&D expenditure (Wallsten, 2000). Moreover, Elsnasri and Fox (2014, 2015), point out that R&D is not the only source for innovation, hence claiming that government support should not be focused only on tax subsidies for R&D expenditure, but rather allow for impact through other means also.

There are many analyses of the effects of input 'additionality' (the effects of the public support to the R&D expenditure of the firms), 'crowding in' (when public investments actually increase demand and stimulate private investments) and 'crowding out' (when public investments drive down private market investments). Input additionality is important and, as such, has been one of the indicators of innovativeness of countries in OECD reports. However, evaluating innovation programs and policies only with this indicator is certainly insufficient.

In order to assume that public support will directly increase the R&D expenditure of firms, two ideal conditions are needed, as noted by Lach (2002): first, firms cannot undertake the innovative project without the public support; second, other firms' innovation will not offset this by being adversely affected because of this support.

Attracting additional investments on the market (known as 'crowding in') after receiving public funds, can be achieved by the firm if the private sector sees the government's support as a signal of a quality innovative project, and from all firms' viewpoint, additional effects of the public funding can be spillover effects of the gained knowledge and know how.

The opposite effect of 'crowding in' is the 'crowding out' effect, which happens when the public funds are being wasted and would have been replaced with private funds instead.

Governments, almost without exception, being instinctively risk-averse, led by politicians with programs implemented by bureaucrats, tend to 'pick winners' or 'cream skim' for public support, or choose previous program participants (the so-called 'Matthew effect', as noted by Crespi and Antonelli 2012), as those projects have higher probability of success, that will justify their budget spending and will give them a better reputation in the public's eye and so the voter will re-elect them (Czarnitzki and Lopes-Bento 2013; Nooteboom and Stam 2008; Stiglitz and Wallsten 1999; Wallsten 2000; Zunica-Vicente *et al*. 2012).

This kind of government strategy leads to crowding out or financing of projects that would have been financed and undertaken by firms even in the absence of public support.

This literature review is focusing on 'output additionality' because, in order to achieve the final goal of innovation, which is to increase economic growth, innovations must be commercialised and improve the productivity of the firms. In order to assess achievement of that goal, instead of the cross-sectional data that most studies use, longitudinal data is used here instead to investigate the medium and long-term effects better.

Most of the existing studies have concluded there is positive output additionality (Hall *et al*. 2008; Hussinger 2008; Aschhoff 2009; Herrera *et al*. 2010; Lopez-Acevedo *et al*. 2010; Reinkowski *et al*. 2010; Crespi *et al.* 2011; Czarnitzki *et al*. 2011; Alecke *et al*. 2012; Herrera *et al.* 2012; Foreman-Peck 2013). Only one study found evidence of negative output additionality, that public support actually crowds out (Marino *et al.* 2010).

Different studies have used different proxies for the innovation output: product innovation (Hall *et al*. 2008; Crespi *et al*. 2011; Hujer *et al.* 2005: Hewitt-Dundas *et al*, 2010); process innovation (Hall *et al*. 2008; Marzuccchi 2011); product and process innovations (Hall *et al*. 2008; Lopez-Acevedo *et al*. 2010 Foreman-Peck 2013); innovative sales (Hall *et al*. 2008; Hussinger 2008; Aschoff 2009; Cerulli *et al.* 2010; Garcia *et al.* 2010; Lopez-Acevedo *et al*. 2010; Schneider *et al.* 2010; Hewitt-Dundas *et al.* 2010; Marzucchi 2011; Herrera *et al.* 2012); labour productivity (Lopez-Acevedo *et al*. 2010; Crespi *et al*. 2011); and profitability (Lopez-Acevedo *et al*. 2010; Czarnitzki *et al*. 2011).

However, almost all the studies focused both on input and output additionality, and only one study looked solely at the effectiveness of the innovation intervention through output additionality (Foreman-Peck 2013).

Regarding the empirical strategy these studies are using, most of them are using 'propensity-score matching', then 'difference-in-difference' methods, then 'semi-parametric' and 'parametric' selection models.

4.3 Economic and policy context in Australia

Looking now at the specific case of Australia, this section briefly describes its innovation policy framework. At its core, Australia's university system is good, with universities taking 31% of the GERD (Australian Innovation System Report 2017). However, Australia stands not as high on innovation[45] and commercialisation compared to other high-income countries, even though there has been steady economic growth for more than two and a half decades. A linear innovation model and bad choice of public financing mechanisms for innovation are some of the reasons for this situation.

Australia has the mantra that 'the government cannot pick winners' (Innovation and Science Australia 2017), hence it focuses instead on generic approaches, sometimes too vague and over-inclusive for effective innovation policies.

For the past 30 years of innovation policy, and more specifically for business financial support, Australia has predominantly focused on indirect incentives such as R&D tax concessions. Correspondingly, Australia doesn't have many 'new-to-market' innovations; rather it is a follower in innovation, where firms adopt technologies. Australia is almost the only OECD country which focuses predominantly on indirect incentives rather than on direct. Direct support (grants) comprise only 12% of the total financial support. In the US it is up to 70% (Australian Innovation System Report 2017). Another problem is inconsistency of policy. There have been more than 10 changes to R&D tax concession provisions and numerous changes of other innovation programs since 1980s. Moreover, if Australia wants to shift towards 'new-to-market' innovation, and be a leader in innovation, focus must be given more

[45] According to the Global Innovation Index 2019 report, Australia's innovation score of 50.34 placed it 22nd.

to young and high-growth firms rather than bigger, older firms. Instead of radically innovating, bigger firms tend to improve their current competencies, while young, small and high-growth firms are more inclined towards radical, new-to-market innovations (Baumol 2002; Henderson 1993; Vaona and Pianta 2008).

In Australia, assistance for entrepreneurs and SMEs to commercialise their innovations can be divided into three broad groups:

- R&D and innovation programs, including grants for commercialisation and R&D tax incentives and concessions
- clean technology programs (which are targeted programs)
- venture capital programs.

Although all of these initiatives are necessary in different stages for successful innovations, this essay seeks to explore in depth the effects of commercialisation grants on the innovative activities of entrepreneurs and SMEs.

Because of data availability, this essay evaluates the impact of commercialisation grants for innovations from 2006 to 2011. The background for this is that from 1983 until 1996, public support for business innovations was only through indirect instruments (R&D tax concessions). From 1996, in addition to the ongoing R&D tax concessions, other programs were added as well as the R&D Start grants program (loans for innovations). Then Commercialising Emerging Technologies replaced the START program, which was subsequently replaced with the Commercial Ready program in 2004, which was slightly modified in 2007 and renamed the Commercial Ready program. This targeted early growth, small and emerging spin-off companies with matching grants between $50,000 and $5 million for R&D, proof-of-concept[46] and early-stage commercialisation.

Some 524 projects were so supported with total of $493.72 million. In 2009–10, a new program, Commercialisation Australia, incorporated the above-mentioned Commercial Ready program, with funding of approximately $270 million for five years until 2013–14, for improving skills and knowledge, developing proof of concept and early stage commercialisation, in amounts of $50,000 to $2 million. For five years, 607 projects were supported in total to $231.6 million.

4.4 Methodology

4.4.1 Estimation strategy

This essay evaluates government subsidy policy in Australia using empirical analysis, with the main objective being to estimate the effect of public financial support in the form of grants implemented for innovative entrepreneurs in Australia. The essay looks at the impact of the grants on firms' innovative performance, starting from the proposition that considering only the input side of the innovation efforts is not sufficient condition to evaluate the impact, as discussed in Section 2 of this essay.

This essay estimates the effect of public financial support in form of grants for innovation and examines the issue of whether policy has influenced the probability of the firm to have new goods and services, operational processes innovation, organisational/managerial processes or marketing methods innovation. Further, the question of the impact of grants on the

[46] Evidence that the pilot project or the idea is feasible.

competitiveness of beneficiaries (labour productivity, sales and employment) was considered.

In the evaluation strategy, the model for the relationship between firm's investment and innovation output and productivity proposed by Crepon *et al*. (1998), and later used by Hall *et al*. (2008) in their extensive evaluation of Latin American funds for financing business innovations, is used. Hall *et al.* (2008) adapted the model to reflect the real nature of the innovations seen in surveys where innovations measures are based on subjective judgments of the owners for 'new-to-firm', rather than objective measures such as patents, R&D expenditure with usual 'new-to-market' innovations, especially in Australia, following OECD methodology in the Bogota Manual (OECD 2000). These are the model benchmarks for developing the analysis here.

Empirically, most of the studies so far have used non-parametric[47] matching techniques owing to lack of available longitudinal panel data. As this estimation uses longitudinal data, both parametric and non-parametric modelling are used.

The fact that there is a possible two-way relationship between firm performance and participation in government business programs (the performance can affect the likelihood of getting the grant and how it responds to it) may lead to estimation biases.

Endogeneity of the public support for innovations may arise from different sources, for example, the selection process, which is non-random, rather than support being given to

[47] Parametric techniques assume finite sets of parameters and known functional form; on the other hand, non-parametric techniques can capture more subtle aspects of data as they assume infinite set of parameters and no assumption of the functional form (Smith 2000; Smith and Todd 2003). Hence the later are much more flexible.

those firms that have bigger propensity to innovate (cherry picking), such as larger established or high tech firms (Wallsten 2000; Gonzáles *et al*. 2005; Aerts and Schmidt 2008; Alecke *et al*. 2012; Czarnitzki and Lopes-Bento 2013) versus firms which are self-selecting and would finance themselves privately otherwise (Busom 2000; David *et al*. 2000; Aerts and Schmidt 2008; Grilli and Murtinu 2011). While the fixed effects models are able to control for potential correlation between unobserved heterogeneity and time-varying explanatory variables, the endogeneity issue is a task for future research.

To implement the approach taken, this section will discuss three dimensions of the empirical methods adopted:

- ordinary least squares analysis
- fixed effects model
- propensity-score matching.

First though, it is helpful to say briefly what methods have not been pursued further in this study and why, although some of them might tackle the issue of endogeneity better. This essay doesn't use differences in differences because there is no baseline year from the start of the treatment, as different firms received their public funding in different years. This essay doesn't investigate input additionality because: (1) the dataset lacks information on R&D expenditures of the firms (the studies usually used to investigate input additionality had binary measures for R&D, rather than the amount of subsidies, hence without the size, cannot be properly modelled) ; (2) having longitudinal data, capturing the medium and long-term effects on firms' performance are of more interest than focusing on how much firms R&D

expenditure increased; (3) SMEs invest proportionally less in R&D than big firms, or in more informal ways (Lefebvre and Lefebvre, 1993).

This essay is not using the instrumental variables methodology owing to lack of adequate instruments (the author cannot find a variable that affects the selection for the grants, but not the outcome). Further, this essay cannot use the regression discontinuity design, because the grant recipients are not selected on an observable variable[48] or some deterministic process, especially due to the constant changes to the grant programs over time, as described above.

The three empirical methods that are instead relied upon are developed now in further detail in this section. This discussion precedes the following Section 5 that discusses the data deployed for analysis, and Section 6 which reports the results from this analysis. Section 7 provides conclusion for this policy evaluation of this Australian innovation strategy.

4.4.1.1 Ordinary least squares analysis

The first approach adopted is an ordinary least square regression model (OLS). This approach elucidates whether there is a correlation between the treatment variable (which is receiving the grant) and different outcome variables, while controlling for other observable factors. The OLS model is:

$$I_{it} = \alpha + \beta \, financial\ grant_{it} + \delta \, X_{it} + \varepsilon_{it} \tag{30}$$

[48] At least not observable to the author and to her knowledge.

$$Ln(BP)_{it} = \alpha + \beta \, financial \ grant_{it} + \delta \, X_{it} + \varepsilon_{it} \qquad (31)$$

Following Hall *et al.* (2008), Equation (30) represents a linear relationship between innovation output (I) by firm *i* and year *t*, and dummy variable $financial \ grant_{it,}$ 1 if firm *i* received a grant and 0 otherwise, firm's observable characteristics *X* and an error term.

As innovation output, five different outcome variables are used. These are all binary variables, taking value 1 if the firm *i* has introduced the appropriate innovation type, or 0 otherwise: (1) whether the firm has introduced new or significantly improved products (goods and/or services), operational processes, organisational/managerial processes and marketing methods innovation; (2) whether the firm has introduced new or significantly improved goods and/or services; (3) whether the firm has introduced new or significantly improved operational processes; (4) whether the firm has introduced new or significantly improved organisational/managerial processes; (5) whether the firm has introduced new or significantly improved marketing methods.

Following Hall *et al.* (2008), Equation (31) represents a log–linear relationship between business performance indicators $Ln(BP)_{it}$ for firm *i* and year *t*, and dummy variable $financial \ grant_{it,}$ 1 if firm *i* received a grant and 0 otherwise, firm's observable characteristics *X* and an error term. As business indicators, three different outcome variables are used: labour productivity, total sales and total employment.

The analysis of the data starts with the replication of the model of Crepon *et al*. (1998) and later Hall *et al*. (2008) (hereafter the Baseline Model or Model 1), where they focus on different sets of outcome variables, as innovative outputs (goods and/or services innovation, operational process innovation) and business performance indicators (labour productivity, sales, employment). As there are more types of innovative outputs available for this analysis, they are incorporated in an extended model. All independent and dependent variables are presented in Table 4.1 below.

Table 4.1 Variable definition

(continued next page)

Variable	Definition	Scale
Dependent Variables		
Innovation introduced	Introduced any new or significantly improved: goods and/or services; operational processes; organisational/managerial processes; marketing methods	0/1
Goods and/or services innovation	Introduced any new or significantly improved: goods; services	0/1
Operational processes	Introduced any new or significantly improved: methods of manufacturing or producing goods or services; logistics, delivery or distribution methods for goods or services; supporting activities for business operations; other operational processes	0/1
Organisational/ managerial processes	Introduced any new or significantly improved: knowledge management processes; organisation of work; business practices for organising procedures; methods of organising work responsibilities and decision-making; significant changes in relations with others; methods of organising external relations with other businesses or institutions; other organisational/managerial processes	0/1
Marketing methods	Introduced any new or significantly improved: design or packaging of a good or service; media or techniques for product promotion; sales or distribution methods/methods of product placement or sales channels; methods of pricing goods or services; other market innovation	0/1
Labour productivity	Total sales divided by total employment (number of persons working for the firm)	

Sales	Total sales; A$ million	
Employment	Number of employees working for this firm	
Independent Variables		
Ratio exports/sales	Share of exports in total sales; A$ million	
Firm age	Business years in operation	
Foreign owned	Business reports any degree of foreign ownership	0/1
Collaboration – R&D	Has a cooperative ('collaborative' from 2007/08 onwards) arrangement for joint research and development	0/1
Location	Number of locations operated	1/5
Capital expenditure	Purchases of business assets like plant and equipment including machinery, cash registers, computers, furniture and motor vehicles; also, any land or buildings.	
Tax incentive	Received tax concession for innovation	0/1
Industry controls	Industry division 2006 (Panels 3 onwards designed on ANZSIC06)	1/19

Source: *ABS*

This study uses different sets of control variables to capture different effects on the outcome variables. The research starts with Model 1, where Hall's model (2008) is replicated, and for the dependent variables labour productivity and sales, explanatory variables total sales, ratio of exports in the total sales, average wage and year dummies, are used; for explaining the effects on the total employment, this study uses total sales, firm age and an industry dummy. While for the innovation outputs, this study uses ratio of exports in total sales, total employment, firm age, capital expenditure[49] and an industry dummy. The prediction that innovation will be a function of firm age is mixed one and leaning more towards the negative

[49] Hall *et al*. (2008), instead of capital expenditure, used investment in machinery, but as those data are not available for this research, as a proxy the capital expenditures are used.

correlation between those two (Becheikh 2006; Chang-Yang Lee 2009). The older the firm usually the less flexible and less innovative but that might be due to some other factors left out from the models.

Foreign ownership as a measure for the relationship between innovation and globalisation has overwhelming evidence in the literature (Becheikh et. Al 2006; Chang, Chen and McAller 2013). Firms who export tend to be more innovative, but there is still unclear causation. Do more innovative firms tend to export more or vice versa? Becheikh et al (2006) through their review of 108 studies found mixed results regarding this variable and propensity to innovate.

Industry dummy is important as the industry environment gives the confidence the firms to invest in innovations (Harris and Trainor, 2011). Innovators with lower technological competence might benefit more from certain industry clusters, while the higher skills innovators might risk more due to potential knowledge spill overs onto the other competitors.

In the second model (hereafter Model 2), this analysis adds joint collaboration for R&D in Model 1. Collaboration between SMEs and other actors in the national innovation systems is important, as the knowledge is predominantly transmitted through interactions and limitations (Cassiman and Veuglers 2005; Roper *et al*. 2008).

In the third model (hereafter Model 3), Model 2 is further enriched with information for an industry dummy to capture the different technological opportunities that vary between sector; foreign ownership, location (how many locations the firm operates in) and year dummy, to control for the macroeconomic environment (if it was missing in the baseline model).

In the end, this research also captures the potential effects of tax incentive on innovative outputs and business performance, hence this research ends up with the Final Augmented Model (hereafter Model 4), where a dummy for tax subsidy is added to Model 3.

In the regression analysis, the focus is on the effects of participating in the grant program, while controlling for other determinants of the business innovative performance. This research tries to balance between having too many variables which will lead to spuriously 'significant' results and omitted variable bias which would be a failure to properly incorporate all the important variables, further leading to loss of significant information and moreover resulting in biased coefficients in some cases. Unfortunately, many variables are not controlled for owing to lack of data, as important firms' characteristics include unobservable characteristics such as motivation, risk-taking, and skills. Further, this estimation did not simply seek to improve the fit of the model by maximising the R2 through more variables rather it seeks to improve understanding.

4.4.1.2 Fixed-effects model

The panel data facilitates understanding of between-firm and within-firm variability to estimate the impact of public grants on firms. Fixed-effects models can mitigate some potential selection bias, if unobserved heterogeneity is constant over time. In the absence of a single model of characteristics of firms' innovation, as there are many characteristics, and following Hall *et al.* (2008) the following model is specified:

$$I= \delta+ \mu+ \alpha Y+ \beta X+ \varepsilon \quad (32)$$

$$Ln(BP)= \delta+ \mu+ \alpha Y+ \beta X+ \varepsilon \quad (33)$$

where *I* is the outcome variable.

This research considers two variants. The first variant (32) is whether the firm has introduced new or significantly improved products, operational processes, organisational/ managerial processes or marketing methods innovation, as a binary variable taking the value 1 if the firm has introduced innovation and 0 otherwise. For this model, conditional logistic fixed effects are used.

As the focus of the research is SMEs, patents are not used as an innovation measure because small firms rarely use them, or patent activity is not formalised (Jaumotte and Pain 2005, p. 25).

The second variant of the equation recognises that innovation is not the goal per se, but rather it is to achieve further economic development. The main interest therefore is in evaluating the firms' productive performance. Whereas, for the firm, performance indicators (33), labour productivity, total sales and total employment are used. In the second variant of regressions a simple log–linear functional form is adopted, which is at best a local approximation to the effects of government programs and other variables affecting firm performance.

In this essay labour productivity is defined as sales divided by total employment (number of people working for the firm). It is recognised that a better variable might be the total factor productivity (TFP), but TFP needs more data, which is not available for this research and assumption on the functional form. Therefore here:

Y is binary treatment variable having value 1 if the innovative firm received grant from Australian government and 0 otherwise, the coefficient α estimates the average impact of the grants over the whole time period; δ captures all the individual fixed effects (both observable and unobservable) which are fixed over time but vary between the firms; μ captures the time effects but are constant amongst firms; X is the vector of firm-level control variables; and ε is the usual error term. The impact of the grants on the outcome variable will be a consistent estimator, alpha α, if time-constant unobserved heterogeneity is assumed. This model controls for stable characteristics, but unfortunately such variables cannot explicitly be in the model, such as firm size.

As explained above, this research uses four models to capture different effects on the outcome variables. In the Baseline Model, Model 1, the replication of the Hall's model (2008), for the dependent variables labour productivity and sales, the following independent variables are used: total sales, ratio of exports in the total sales, average wage and year dummies. While for the innovation outputs, the explanatory variables are ratio of exports in the total sales, total employment, capital expenditure[50] and industry dummy.

Model 2 controls for joint collaboration for R&D. In Model 3, an industry dummy is added which is used to capture the different technological opportunities that vary between sectors, foreign ownership, location and year dummy to control for the macroeconomic environment. Model 4, the Final Augmented Model, incorporates the financial tax subsidy for firms as well.

Using this methodology, the total average impact during the whole period is estimated as it allows for accommodation of the specific structure of the data. Fixed effects allow more

[50] Hall *et al*. (2008), instead of capital expenditure, used investment in machinery, but as those data are not available for this research, as a proxy the capital expenditures are used.

flexible regression design taking into consideration moving years of receiving the grants, macroeconomic environment, using multiple programs, and different varying time since the start of the grant.

Estimators shall be consistent, under the identification assumption of time-constant unobserved heterogeneity, but if firms' recipients and non-recipients differ in unobserved time varying factors and are heterogenous, the assumption is not likely to be met. Hence, using propensity-score matching will help in mitigating these kinds of biases, as regressions will be run in a common support of firms, similar in ex-ante characteristics.

4.4.1.3 Propensity-score matching

Propensity-score matching pairs firm recipients of grants with an observably similar non-recipient and interprets the difference in those estimators as the effect of the grants. The main assumption is that observable characteristics drive the program participation.

Matching is non-parametric and, as such, doesn't depend on the functional forms, hence reducing the bias (Smith 2000; Smith and Todd 2003). The main purpose of matching as quasi-experimental design is to establish the counterfactual[51] in the absence of randomisation as a true experiment.

[51] A conditional with a false 'if' clause. What would have happened with the innovative activities of the firms recipients if they didn't receive the grant for innovation?

Following Hall *et al.* (2008), let Y(1) denote the outcome if the firm receives the grant and Y(0) denotes the outcome if the firm doesn't receive the grant, and D is a dummy variable denoting whether the firm received the grant. The average treatment effect would be:

$$ATT= [E(Y(1)\mid D=1]- [E(Y(0)\mid D=1] \quad (34)$$

In order to estimate (34) a counterfactual $[E(Y(0)\mid D=1]$ is needed*,* what would have happened to the firms which have undertaken innovative activities if they didn't receive the government's financial support? In reality, this is the main challenge, because it can't be observed.

Hence, a suitable control group (Y=0) must be set of firms which don't receive the treatment (public financial support) which can be observed for innovative projects which will minimise the potential endogeneity and selection bias problem. This problem arises because the public financial support is endogenous to the firms' innovation behaviour, as both of them are influenced by observable and unobservable characteristics of firms.

Therefore, a control group from the non-recipients of the public support cannot be simply formed, as they might not have received support because of their characteristics. For example, they are a smaller size than the firms' recipients and innovating less is a result of their size rather than the public support, or they innovate less so they are less likely to apply for the public support or because the government chooses recipients based on 'cream skimming'. The latter introduces selection bias $[E(Y(0)\mid D=1]-[E(Y(0)\mid D=0]$, which causes overestimation of the average treatment effect.

$$ATT= [E(Y(1)\mid D=1]- [E(Y(0)\mid D=1]-[E(Y(0)\mid D=0]+ [E(Y(0)\mid D=0]$$

$$ATT + bias = [E(Y(1)\,|D{=}1] - [E(Y(0)\,|D{=}0] \quad (35)$$

If the public financial support was given randomly, that bias wouldn't be a problem, as both observed and unobserved characteristics would be balanced across the recipients (treatment group) and non-recipients (control group). But as the innovative financial support is never given to the recipients randomly, rather based on observed characteristics, to address and deal with these abovementioned problems, this essay employs quasi-experimental strategy.

The strategy is propensity-score matching in order to evaluate the causal effects of the public support on firms' innovative activities. The main identification assumption is that the innovative firms are affected by observed characteristics. The assumption is that all the differences between the treatment and control group are in the observable characteristics (e.g. size of the firm and age), which are not affected by the treatment.

The propensity-score matching technique allows for constructing a statistical group that is similar in many dimensions to the treated group, based on observed characteristics and depends on conditional independence (a set of observable covariates X exists, which can be controlled for and which is not affected by the treatment, hence potential outcomes are independent on the treatment assignment) (Caliendo *et al.* 2005).

Propensity-score matching, accounts for unobserved characteristics while controlling for the potential selection on observables. The potential for unobserved characteristics to influence the results is reduced as the comparison is only between 'similar' firms. Logit specification is used to estimate the propensity score, where the firm's participation is identified by the binary dependent variable.

The propensity score measures the probability of a firm of receiving the public support (the selection in the treatment), given the pre-treatment characteristics, such as firm's size and age. Firm size is used as pre-treatment characteristic to reflect the market position of the firm (many studies didn't show significant effect on the innovative performance) (Cohen and Levin 1989; Kleinknecht and Reijnen 1991).

The model only matches grant recipients with non-participants within the same industry (with the same two-digit industry code), which allows analysis to account for all industry-specific factors. Then, based on this probability, a five nearest neighbours matching procedure is used to match the participants with non-participants (also, the Kernel matching procedure is used to check the robustness of the results), after which the average treatment effect is calculated as the difference in outcomes between the two groups, and firms from the control group which are outside the common support area are eliminated.

Hence the impact of the public support program is observed over the common support area in which there is an overlap in propensity scores across recipients and non-recipients. If the number of the covariates is high, it would not be possible to find any control observation and should be avoided as the overspecification can result in higher standard errors of the propensity score (Shahidur *et al.* 2009). The propensity-score model is defined by Rosenbaum and Rubin (1983):

$$p(X)= Pr(D=1|X) \quad (36)$$

According to equation (36), the probability of receiving the grant *(p(X)),* is equal to the probability of a firm with observable characteristics X receiving the grant. Then, the average treatment effect can be calculated:

$$ATT = E[E\{Y(1) \mid D=1, p(X)\} - E\{Y(0) \mid D=0, p(X)\} D=1] \qquad (37)$$

The average treatment effect on the treated is the net effect of the policy, in this case the grants for innovations.

Although this approach has strengths, as the assignment to treatment or control can be considered random (Becker and Ichiro 2002), it also has a few problems. As the data are not cross-sectional rather than panel data, especially to do matching techniques while dealing with a moving year of entry for the firms, can be problematic, as PSM techniques works with cross-sectional data.

To investigate this, the study used the following methodology. First, a logit regression is run on the firms that received the treatment in 2006–2007. Second, the propensity scores for the treatment group are derived and the common support is computed. This ‘cross-section’ PSM approach theoretically is more robust because the drivers for receiving the grant change from year to year and can deal with the lack of single year of entry and assign a unique propensity score for each firm’s observation in the sample.

In the data panel, there is no firm exit during the five-year period which might lead to potential bias. Hence, in order to test for the sensitivity of the estimates of the treatment effects, following Mckenzie and Woodruff (2007), the 5% of the treatment group in each outcome are trimmed. With that, the assumption is that the worst performing firms, if they didn’t receive the grant, would have exited, and only the firms who would have been successful enough to stay can be matched.

4.5 Data for innovation analysis

This empirical analysis uses a confidential[52] balanced panel Business Longitudinal Database (BLD) dataset from the Australian Bureau of Statistics (ABS), of 15,375 observation for 3,075 Australian SMEs for the period 2006–07 to 2010–11. The time of analysis is financial year rather than calendar year. The population consists of firms with less than 200 employees.

More than half of the business units (almost 60%) included in the dataset have introduced some sort of innovation. The type of innovation introduced was evenly split between new goods and services, operational processes, organisational/managerial processes, and new marketing methods. It is interesting to note that innovative firms often have more than one type of innovation.

The dataset includes a subset of innovative 1,731 SMEs (7,926 firm-year observations), out of which 326 innovative SMEs who received grants from the Australian government, meaning 19% of all innovative firms have a positive grant value. Every type of innovation was introduced by around 1,000 firms. The advantage of this dataset for evaluating the impact of direct funding for business innovations is its size. Most of the studies so far have used only cross-sectional dataset and could evaluate the short term, rather than examine long-term effects of funding on innovation output.

[52] Access to the dataset is managed by ABS to protect privacy and confidentiality. The author applied and was approved by the ABS before accessing the dataset. Data is released using methods and systems that protect the confidentiality of businesses at the discretion of the Australian Statistician after an assessment process conducted by the ABS. In response to the legislative requirement for the Australian Statistician to release data 'in a manner that is not likely to enable the identification of the business', the ABS:

- removes all directly identifying information
- ensures data items are unlikely to identify respondents by the application of a number of different confidentialisation methods
- checks for records with uncommon combinations of responses, and may alter them slightly to ensure businesses cannot be identified.

Theoretical postulates regarding long-term effects have been considered by Czarnitzki (2002) who claimed that absence of the public funding for innovations can have two impacts: lowering the amount of the firm's innovative activity, or not undertaking innovative activity at all. In order to test for that in this empirical analysis, two estimation samples will be used:

First, for the purposes of this analysis the full sample of SMEs in Australia is used. That approach assumes that the innovative grant recipient firms would not have undertaken any innovative activities without the public financial support (grant). Hence, it will compare them with all firms, regardless of whether they innovate.

Second, this research will use a subsample with only innovative firms.[53] The comparison will be done between the grant recipients and the non-recipients, to see if the results from the previous model were affected by non-innovative firms, in that way checking the robustness of the results. However, the lack of public support will not allow firms to change status from innovative to non-innovative, so the treatment effect might be underestimated.

The BLD covers a relatively short period for this study's purpose. There is no opportunity to merge different five-year BLD into one owing to the confidentiality ethics issues of working with the Australian business datasets. BLD does not indicate whether a certain firm might have received a grant in the past. Treating the lapsed participation as permanent non-participants now will bias the estimates. The performance of the non-participants can partly reflect the past grants they received, meaning the performance of the participants now only

[53] The firms in the subsample were chosen on the basis if their business focus had at least innovation measures to a small, moderate, or major extent. Only the firms with not-at-all innovation focus were excluded.

incompletely captures the long-run effects of the financial grants. This cannot be solved with differencing.

To evaluate the recipient firm-level Australian data, the empirical analysis starts with a Baseline Model (Model 1) which is the replication of Hall *et al.* (2008). It continues the analysis with two intermediate models (models 2 and 3), until the Final Augmented Model (Model 4) is reached. The results are reported in Section 6. As more data is available on Australia firms than Hall *et al.* (2008) on Latin American firms, the models are not only testing the validity of Hall's work but including important explanatory variables in extended models for more information. The remainder of this section discusses the data and measurement dimensions further.

Table 4.2 depicts the descriptive statistics with the mean and standard deviation for these variables. About one third of all firms, regardless if they received public financial support had introduced any kind of innovation, and almost two thirds of firms who received grants had introduced any kind of innovation. The type of innovation introduced was similar for new good or service; operational processes; organisational and/or managerial processes; and marketing methods, with almost 40% of all firms introducing some kind of innovation. However, the propensity for introducing some sort of innovation was almost double for grant recipients, with 72% of firms introducing organisational and/or managerial process and marketing innovation. The mean value of total sales, total employment, and labour productivity were much larger for innovative firms than for all firms. Average firm age was close to 11 years. 13.5% of all innovative SMEs had participated in R&D collaboration, while only 11% of innovative firms which were grant recipients had participated in R&D collaboration.

Table 4.2 Data description and list of variables

Variables	ABS sample		ABS subsample–innovative firms		Innovative firms–grant recipients	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
			Output dependent variable			
Innovation introduced (1/0)	0.33	0.47	0.41	0.49	0.59	0.49
Goods and/or services innovation (1/0)	0.4	0.49	0.48	0.5	0.63	0.48
Operational processes innovation (1/0)	0.43	0.49	0.51	0.5	0.72	0.45
Organisational/managerial processes innovation (1/0)	0.41	0.49	0.49	0.5	0.73	0.45
Marketing methods innovation (1/0)	0.36	0.48	0.44	0.5	0.66	0.47
Sales (in AUD)	3596041	1.24e+07	4552844	1.40e+07	4545612	9545445
Total employment	8	8.84	9.6	9.33	11.67	9.73
Labour productivity	313998	1126307	345638	1057346	281831	431416
			Independent variable			
Grant recipient (1/0)	0.07	0.255	0.08	0.27	0.42	0.49
			Control variables			
Ratio exports/sales	0.04	0.46	0.04	0.39	0.08	0.83
Capital purchases	127561.4	828839.3	160985.7	975482.2	205801.2	771470.1
Location	1.14	3.18	1.56	1.11	2.18	1.46
Firm age	11.5	6.12	11.7	6.06	13.16	5.81
Foreign ownership	0.04	0.19	0.05	0.2	0.04	0.19
Collaboration (R&D)	0.05	0.2	0.06	0.23	0.12	0.32
Tax incentive	0.028	0.165	0.034	0.181	0.077	0.26
Financial year	2007	143	200799	141.82	200805	142.74

Source: ABS; Author's calculations

Table 4.3 compares the ABS sample with the population of all firms regardless their innovative status, with one subsample of all the innovative firms and the other subsample of only innovative firms who received grants for innovation from the Australian government. The data show an over-representation of firms in agriculture, forestry and fishing, mining, manufacturing, wholesale trade, information media and technology, arts and recreation, and an under-representation of firms in construction, retail trade, rental, hiring and real estate services, professional, scientific and technical services. Apart from these minor differences, the sample is broadly representative.

The subsample of innovative firms represents fully the sample of SMEs in the dataset, with a fifth of the innovative firms having an agriculture, forestry or fishing business focus, 16% with manufacturing focus, followed by 10% of the wholesale trade firms, with the rest being around 5%. However, more than one third of all innovative firms who received grants were in agriculture, forestry and fishing industry[54].

[54] Further research shall estimate model without those industries to check the robustness of the results.

Table 4.3 Counts of innovative SME firms

Industry Division (ANZSIC06)	ABS population counts		ABS sample counts		ABS BLD sample innovative firms		ABS BLD sample innovative firms who received grants	
	June 2007	Share	2006–07/2010–11	Share	2006–07/2010–11	Share	2006–07/2010–11	Share
Agriculture, Forestry and Fishing	190431	15.1	655	22.6	347	20.1	112	34.3
Mining	4207	0.3	109	3.8	57	3.3	<10	<3
Manufacturing	71490	5.7	409	14.1	291	16.6	60	18.2
Construction	261584	20.8	134	4.6	69	3.9	<10	<3
Wholesale Trade	57072	4.5	264	9.1	174	9.9	27	8.2
Retail Trade	113635	9.0	151	5.2	106	6.2	13	4.0
Accommodation and Food Services	67959	5.4	167	5.8	94	5.7	12	3.6
Transport, Postal and Warehousing	83306	6.6	135	4.7	67	3.9	<10	<3
Information Media and Telecommunications	11068	0.9	146	5.0	103	5.9	18	5.8
Rental, Hiring and Real Estate	98321	7.8	148	5.1	72	4.2	10	3.0
Professional, Scientific and Technical Services	160542	12.7	147	5.1	95	5.4	10	3.0
Administrative and Support Services	52788	4.2	135	4.7	70	4.1	10	3.3
Arts and Recreation Services	17838	1.4	154	5.3	93	5.3	21	6.4
Other Services	69712	5.5	145	5.0	93	5.4	<10	<3
Total	**1259953**	**100**	**2899**	**100**	**1731**	**100**	**326**	**100**

Source: ABS, Author's calculations

Table 4.4 shows that nearly half of the innovative firms were registered companies, one in five were partnerships, one in six were trusts, and one in seven were with one owner. The situation is almost identical for the innovative firms who are grant recipients as well, with one difference, partnerships were more likely to get grants with one in four firms being that type, while sole ownerships, dropped to one grant recipient in 14 firms.

Table 4.4 ABS subsample of innovative firms by type of legal organisation

Type of legal organisation	Innovative firms (percentage)	Innovative firms who received grants (percentage)
2006–07 to 2010–2011		
Registered company	48.5	49.3
Sole proprietor	14.8	7
Partnership	19.5	25.5
Trust & other unincorporated entities	17.2	18.2
Total	100	100

Source: ABS, Author's calculations

Table 4.5 shows that the percentage representation of different firm sizes between all SMEs in the sample, innovative SMEs, and innovative SMEs which received public grant, is different. Almost one third of the firms in the sample were without employees. However, only 15% of those firms received grants for innovations. The larger the firm, the more chance of receiving a grant from the government for innovation.

Table 4.5 ABS sample by size of firm

	ABS sample–all firms (percentage)	ABS sample–innovative firms (percentage)	ABS sample–innovative firms who received grants (percentage)
Non-employer	27.6	22.8	15.0
0–4	26.3	24.7	21.0
5–19	23.9	25.4	29.0
20–199	22.2	27.1	35.0
Total	100	100	100

Source: ABS, Author's calculations

4.6 Results

This section reports the results for the two levels of impact evaluation of public grants for innovative firms specified for this study: the impact on innovation outputs and the impact on business performance indicators such as labour productivity, sales and employment.

The analysis first uses the full sample, including observations both for innovative and non-innovative firms, in order to evaluate the effect of the grant on undertaking the innovative activities. The analysis is then restricted to observations for innovative activities only, to estimate the effect of the grant stimulus on the firms' efforts. For both samples, four models are used: starting with the Baseline Model (Model 1), the replication of Hall's (2008), building further by adding different variables for capturing their effects (Models 2 and 3) to the Final Augmented Model (Model 4). For the panel estimates from the full sample, differences in coefficient between the models and baseline model are reported.

For brevity, the full OLS, panel regressions and propensity-score matching estimations for innovation outputs are shown in Subsection 6.1 and the full OLS, panel regressions and propensity-score matching estimations for business performance indicators are shown in Subsection 6.2. Subsection 6.3. contains the summary of the results and the comparison with the existing evidence. In this subsection, the comparison is between the panel estimates from the full sample to make easier the comparison with Hall's model (2008), as Hall *et al.* used only those approaches in their work.

4.6.1 The detailed model statistical estimation analysis that produced these results, summarised in Section 6.3, now follows in Subsections 6.1 and 6.2. Results of firm analysis for innovation outputs

4.6.1.1 Ordinary least squares analysis and estimated results

First, a conventional linear regression model using an ordinary least square model (OLS) is estimated. This method allows examination of the relationship between receiving the grant and all the five variables of interest, while holding constant other observable characteristics of the firms.

These results are presented in Table 4.6. On average across all years, if a firm received the grant it had a 40% greater chance of having any innovation output; 49% more chance of introducing new or significantly improved goods and/or services; 38.5% of introducing innovation in the operational processes; and 35% more chance of having innovative marketing methods. The results for organisational/managerial processes innovation was insignificant.

The results using the OLS are consistently similar to those reported in Subsection 6.1.2. using the fixed-effects model which is discussed in greater detail below. However, when using OLS, all observations are weighted equally which increases the potential for unobserved characteristics to influence the results (Valera 1978). In order to reduce the potential bias, the coefficients are estimated through comparison between 'similar' firms using matching techniques.

Table 4.6 Innovative outputs, OLS, full sample

(continued next page)

Impact Variable	Innovation Introduced (1/0)				New Goods or Services (1/0)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Treatment Dummy (Grant)	**0.406***	**0.316***	**0.319***	**0.245**	**0.618*****	**0.523*****	**0.517****	**0.493****
	0.17	0.184	0.185	0.188	0.187	0.2	0.202	0.204
Ratio Exports/Sales	0.615**	0.499*	0.462	0.436	0.599**	0.538*	0.49	0.471
	0.28	0.298	0.304	0.31	0.29	0.308	0.314	0.318
Total Employment	0.048***	0.048***	0.048***	0.047***	0.029***	0.029***	0.029***	0.029***
	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007
Firm Age	-0.1	-0.008	-0.008	-0.008	-0.022	-0.017	-0.017	-0.017
	0.008	0.008	0.008	0.008	0.009**	0.01*	0.01*	0.01*
Capital Purchases	-5.49E-08	-7.73E-08	-7.62E-08	-7.15E-08	-5.36E-08	-1.35E-07	-1.32E-07	-1.28E-07
	5.75E-08	6.90E-08	6.88E-08	6.76E-08	7.46E-08	1.21E-07	1.20E-07	1.19E-07
Collaboration R&D		1.387***	1.384***	1.33***		0.82***	0.826***	0.802***
		0.305	0.305	0.308		0.284	0.284	0.286
Location			0.000	0.000			0.000	0.000
			0.000	0.000			0.000	0.000
Foreign Ownership			0.139	0.116			0.107	0.100
			0.238	0.240			0.273	0.273
Tax incentive				1.021***				0.280
				0.363				0.355
Industry Controls	Y	Y	Y	Y	Y	Y	Y	Y
Time Dummy	N	N	N	N	N	N	N	N
Sample Size	2228	2065	2050	2050	2198	2045	2031	2031

Impact Variable	Operational Processes (1/0)				Organisational/Managerial Processes (1/0)				Marketing Methods (1/0)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Treatment Dummy (Grant)	**0.437****	**0.409****	**0.402***	**0.385***	0.239	0.088	0.074	0.044	**0.35***	0.331	0.315	0.259
	0.185	0.196	0.198	0.2	0.196	0.212	0.214	0.217	0.207	0.219	0.221	0.225
Ratio Exports/Sales	-0.188	-0.241	-0.378	-0.399	0.392	0.344	0.262	0.229	1.129***	1.088***	1.028***	1***
	0.349	0.349	0.378	0.379	0.3	0.313	0.323	0.328	0.299	0.313	0.319	0.324
Total Employment	0.047***	0.047***	0.046***	0.046***	0.057***	0.059***	0.058***	0.057***	0.032***	0.029***	0.029***	0.028***
	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007
Firm Age	-0.013	-0.013	-0.012	-0.012	-0.006	-0.004	-0.003	-0.003	-0.005	0.001	0.002	0.002
	0.009	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.011	0.011	0.011
Capital Purchases	-2.22E-08	5.14E-09	2.26E-09	3.26E-09	-8.59E-08	-1.56E-07	-1.64E-07	-1.56E-07	-1.12E-07	-8.93E-08	-8.54E-08	-7.87E-08
	5.92E-08	5.78E-08	5.77E-08	5.75E-08	7.73E-08	1.15E-07	1.16E-07	1.15E-07	1.07E-07	1.11E-07	1.10E-07	1.08E-07
Collaboration R&D		0.996***	0.997***	0.979***		1.017***	1.018***	0.989***		0.709**	0.712**	0.657**
		0.280	0.281	0.283		0.288	0.288	0.290		0.304	0.305	0.309
Location			0.000	0.000			0.000	0.000			0.000	0.000
			0.000	0.000			0.000	0.000			0.000	0.000
Foreign Ownership			0.347	0.343			0.210	0.204			0.171	0.161
			0.255	0.256			0.263	0.263			0.285	0.286
Tax incentive				0.206				0.335				0.617*
				0.349				0.355				0.359
Industry controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time Dummy	N	N	N	N	N	N	N	N	N	N	N	N
Sample Size	2204	2049	2034	2034	2209	2052	2038	2038	2228	2065	2050	2050

Notes: *, ** and *** denote coefficient estimates are statistically significant at the 10%, 5% and 1% levels respectively; standard errors are below the coefficients.

Sources: ABS; Authors' calculation

4.6.1.2 Panel estimates: full sample

Table 4.7 summarises the first set of results. Parsimonious model specification is used. Five outcome measures are selected for study: innovation output (any type of innovation); goods and/or services innovation; operational processes innovation; organisational/managerial processes innovation and marketing methods innovation. These outcomes are related to the program variable and control variables: ratio exports/sales, total employment, firm age, capital purchases, cooperation for R&D, foreign ownership, location, tax incentive, industry division, and time.

For all types of innovation output as dependent variable, conditional logistic fixed effects are used, and odd ratios are reported. The fixed-effects model allows to control for unobserved individual time-invariant heterogeneity. However, in non-linear logistic models the incidental parameter problem[55] might arise due to unrestricted individual heterogeneity, leading to biased estimates of parameters[56] (Fernández-Val 2009; Kitazawa 2012; Norton and Bryan 2018). Hence, marginal effects after conditional logistic fixed effects can be problematic and not meaningful. Marginal effects are the probability of a positive outcome assuming that the fixed effect is zero, which might be an unreasonable assumption. In such a model, that is conditional on fixed effects, the odds ratio is more appropriate because it is the effect after holding constant other factors, leaving a much more homogeneous comparison group (Norton and Bryan 2018).

[55] Incidental parameters are the group fixed effects, that conditional logistic fixed effects do not have to estimate (which is the advantage of the model).
[56] Individual estimates cannot be separated from model parameters, hence replacing unobserved individual effects by sample estimates.

All four different models have consistent results and show that the average impact of the program (grants) over the whole period is positive for all five outcomes of interest. Most of the results for innovative outputs are significant at the 1% level (apart from marketing innovation), meaning that the estimates for the treatment variable are less than 1% likely to be due to chance.

According to these estimations, for the grant recipients, a 65% increase in the odds of having an innovation output (any type of innovation) is expected; a 48% increase in the odds of having goods and/or services innovation is expected; a 60.7% increase in the odds of having operational processes innovation is expected; a 56% increase in the odds of having organisational/managerial processes innovation is expected; and a 34.6% increase in the odds of having marketing methods innovation is expected.

Estimates for the treatment variables are consistent between all four different models, when adding new explanatory variables. Apart from reporting the estimates for the treatment variable, it is interesting to note that joint collaboration for R&D has a significant and positive effect on all innovative outputs except for new goods and services. It could be further investigated in future studies why collaboration for R&D is important for process, organisational and marketing innovations. On the other hand, foreign ownership has a significant and positive effect only on new goods and services. Further, controlling for the effects of tax incentive made the estimates for financial grants more robust, as grants are having positive impact on almost all innovative outputs, while the tax incentives have significant and positive impact only on operational processes and marketing methods innovations.

The standard errors of the coefficients for the conditional logistic fixed-effects model are generally higher than those of fixed-effects model, but do not imply a lack of significance nor lack of impact. Allison (2009) tolerates higher errors for these models as a trade-off between bias and efficiency, as this model helps control for the omitted variable bias by having firms serve as their own controls.

Differences in the estimates between different models and the baseline model show that for all innovation outputs, a small decrease in coefficients can be noticed as more variables are added / with the progress from the baseline to the expanded model, but all coefficients remain significant. As more variables are added, the explanatory power of the model is increased and is getting closer to the true parameters of the expended model, hence the expanded model is chosen as the final model. From baseline model to expanded model there is about a 7.5% decrease in the odds of having an innovation output (any type of innovation); 7.8% decrease in the odds of having goods and/or services innovation; 8.4% decrease in the odds of having operational processes innovation; 10% decrease in the odds of having organisational/managerial processes innovation; and 10% decrease in the odds of having marketing methods innovation.

Impact Variable	Innovation introduced (1/0)			
	Model 1 Hall's	Model 2	Model 3	Model 4
Treatment Dummy (Grant)	**1.723*** **	**1.674*** **	**1.66*** **	**1.648*** **
	0.238	0.242	0.241	0.24
Ratio Exports/Sales	0.982	0.984	0.982	0.984
	0.063	0.060	0.061	0.062
Capital Purchases	1	1	1	1
	0	5.07E-08	5.07E-08	5.08E-08
Collaboration for R&D		1.639***	1.699***	1.691***
		0.274	0.286	0.284
Location			1	1
			3.71E-10	3.70E-10
Foreign Ownership			1.258	1.255
			0.439	0.439
Tax Incentive				1.276
				0.263
Industry Controls	N	N	N	N
Time Dummy	N	N	Y	Y
Sample Size	5793	5405	5380	5380

Impact Variable	New goods or services (1/0)			
	Model 1 Hall's	Model 2	Model 3	Model 4
Treatment Dummy (Grant)	**1.561*** **	**1.53** **	**1.492** **	**1.483** **
	0.254	0.259	0.253	0.252
Ratio Exports/Sales	0.914	0.922	0.928	0.929
	0.132	0.128	0.127	0.129
Capital Purchases	1	1**	1**	1**
	0	1.01E-07	1.01E-07	1.01E-07
Collaboration for R&D		1.276	1.308	1.308
		0.231	0.237	0.237
Location			1	1
			4.72E-10	4.72E-10
Foreign Ownership			2*	1.993*
			0.806	0.800
Tax Incentive				1.136

				0.253
Industry Controls	N	N	N	N
Time Dummy	N	N	Y	Y
Sample Size	3964	3721	3760	3706

Impact Variable	**Operational processes (1/0)**			
	Model 1 Hall's	Model 2	Model 3	Model 4
Treatment Dummy (Grant)	**1.691*** **	**1.663*** **	**1.633*** **	**1.607*** **
	0.258	0.262	0.26	0.256
Ratio Exports/Sales	0.888	0.891	0.878	0.864
	0.225	0.227	0.247	0.253
Capital Purchases	1	1	1	1
	0	5.55E-08	5.55E-08	5.55E-08
Collaboration for R&D		1.504**	1.612***	1.603***
		0.253	0.273	0.271
Location			1	1
			6.23E-10	6.23E-10
Foreign Ownership			1.608	1.571
			0.646	0.633
Tax Incentive				1.453*
				0.303
Industry Controls	N	N	N	N
Time Dummy	N	N	Y	Y
Sample Size	4203	3957	3936	3936

Impact Variable	**Organisational/Management processes (1/0)**			
	Model 1 Hall's	Model 2	Model3	Model 4
Treatment Dummy (Grant)	**1.668*** **	**1.549*** **	**1.556*** **	**1.562*** **
	0.25	0.239	0.242	0.243
Ratio Exports/Sales	0.943	0.934	0.927	0.928
	0.126	0.127	0.134	0.133

Capital Purchases	1	1	1	1
	0	6.05E-08	6.05E-08	6.05E-08
Collaboration for R&D		1.453**	1.5***	1.503***
		0.235	0.243	0.243
Location			1	1
			4.70E-10	4.70E-10
Foreign Ownership			1.070	1.085
			0.391	0.393
Tax Incentive				0.883
				0.187
Industry Controls	N	N	N	N
Time Dummy	N	N	Y	Y
Sample Size	4092	3815	3800	3800

Impact Variable	**Marketing methods (1/0)**			
	Model1 Hall's	Model2	Model 3	Model 4
Treatment Dummy (Grant)	**1.452****	**1.373****	**1.373****	**1.346***
	0.224	0.222	0.221	0.217
Ratio Exports/Sales	1.036	1.032	1.035	1.034
	0.068	0.067	0.067	0.067
Capital Purchases	1	1*	1*	1*
	0	9.45E-08	9.45E-08	9.45E-08
Collaboration for R&D		1.451**	1.452**	1.454**
		0.255	0.256	0.256
Location			1	1
			4.70E-10	4.69E-10
Foreign Ownership			1.409	1.387
			0.586	0.578
Tax Incentive				1.489*
				0.338
Industry Controls	N	N	N	N
Time Dummy	N	N	Y	Y

Table 4.7 Panel regression coefficients for innovative outputs, full sample

Sample Size	3796	3545	3527	3527

(continued next page)

Notes: *, ** and *** denote coefficient estimates are statistically significant at the 10%, 5% and 1% levels respectively; standard errors are below the coefficients. Odd ratios are reported. Diff is the difference in the estimates between different models.

Sources: ABS; Authors' calculation

4.6.1.3 Panel estimates: innovative firms only sample

Table 4.8 summarises the second set of results for the subsample of only innovative firms. Again, a parsimonious model specification is used. Five outcome measures are selected for study: innovation output (any type of innovation); goods and/or services innovation; operational processes innovation; organisational/managerial processes innovation and marketing methods innovation. These outcomes are related to the program variable and control variables: ratio export/sales, total employment, firm age, capital purchases, cooperation for R&D, foreign ownership, location, tax incentive, industry division, and time. For all types of innovation output as dependent variable, conditional logistic fixed effects are used, and the odds ratios are reported rather than the marginal effects, as explained in detail in Subsection 6.1.2.

All four models show that the average impact of the program (grants) over the whole period is positive and significant for all innovative output outcomes of interest, except for marketing innovation for which only Model 1 showed significant impact.

According to these estimations, for the grant recipients about 62% increase in the odds of having an innovation output (any type of innovation) is expected; 52.6% increase in the odds of having an goods and/or services innovation is expected; 49.6% increase in the odds of having operational processes innovation is expected; 68.8% increase in the odds of having organisational/managerial processes innovation is expected. The results for the innovation output outcomes are consistent with the panel regressions from the full sample.

Table 4.8 Panel regression coefficients for innovative outputs, innovative sample

(*continued next page*)

Impact Variable	**Innovation Introduced (1/0)**				**New Goods or Services (1/0)**			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model4
Treatment Dummy (Grant)	**1.656*** **	**1.647*** **	**1.632*** **	**1.62*** **	**1.562** **	**1.544** **	**1.532** **	**1.526** **
	0.264	0.272	0.27	0.269	0.28	0.285	0.283	0.282
Ratio Exports/Sales	1.355	1.556	1.564	1.548	0.995	1.053	1.092	1.086
	0.35	0.494	0.499	0.49	0.382	0.401	0.418	0.417
Capital Purchases	1.0	1.0	1.0	1.0	1**	1*	1*	1.0
	5.01E-08	5.49E-08	5.47E-08	5.49E-08	9.63E-08	1.06E-07	1.06E-07	1.06E-07
Collaboration for R&D		1.344	1.39*	1.383*		1.058	1.074	1.073
		0.252	0.262	0.261		0.203	0.206	0.206
Location			1.00	1.00			1.00	1.00
			5.55E-10	5.56E-10			6.03E-10	6.03E-10
Foreign Ownership			2.070	2.084			2.571*	2.56*
			1.009	1.015			1.283	1.277
Tax Incentive				1.241				1.091
				0.299				0.267
Industry Controls	N	N	N	N	N	N	N	N
Time Dummy	N	N	Y	Y	N	N	Y	Y
Sample Size	3898	3643	3635	3635	3964	2831	2825	2825

Impact Variable	Operational Processes (1/0)				Organisational/Managerial processes (1/0)				Marketing Methods (1/0)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model3	Model 4	Model1	Model2	Model 3	Model 4
Treatment Dummy (Grant)	**1.48****	**1.556****	**1.522****	**1.496****	**1.687*****	**1.673*****	**1.669*****	**1.688*****	**1.323***	1.302	1.308	1.272
	0.245	0.264	0.26	0.257	0.27	0.284	0.283	0.287	0.222	0.227	0.229	0.224
Ratio Exports/Sales	1.008	1.06	1.019	0.984	2.26	2.584	2.509	2.588	1.51	1.891	2.172	2.123
	0.442	0.486	0.481	0.469	1.169	1.48	1.457	1.51	0.511	0.843	1.033	1.009
Capital Purchases	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1**	1**	1**	1**
	5.35E-08	5.40E-08	5.40E-08	5.40E-08	5.39E-08	6.21E-08	6.21E-08	6.21E-08	1.17E-07	1.17E-07	1.17E-07	1.17E-07
Collaboration for R&D		1.329	1.435**	1.427**		1.309	1.326	1.33		1.429*	1.432*	1.438*
		0.237	0.258	0.257		0.229	0.232	0.234		0.273	0.275	0.277
Location			1.00	1.00			1.00	1.00			1.00	1.00
			8.85E-10	8.85E-10			5.64E-10	5.64E-10			6.38E-10	6.38E-10
Foreign Ownership			2.376*	2.36*			1.343	1.357			2.461	2.450
			1.195	1.189			0.572	0.576			1.461	1.460
Tax Incentive				1.323				0.789				1.618*
				0.302				0.178				0.409
Industry Controls	N	N	N	N	N	N	N	N	N	N	N	N
Time Dummy	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Sample Size	3203	3017	3001	3001	3115	2917	2911	2911	2934	2752	2739	2739

Notes: *, ** and *** denote coefficient estimates are statistically significant at the 10%, 5% and 1% levels respectively; standard errors are below the coefficients. Odd ratios are reported. Model 1 is Hall's model. Sources: ABS; Authors' calculation

4.6.1.4 Propensity-score matching analysis and estimated results

The third set of results, this time using PSM, are provided in Tables 4.9, 4.10 and 4.11 respectively. The sample is restricted to compare treated with untreated firms which are similar in their pre-treatment observable characteristics.

Pre-treatment matching is done for characteristics: firm's size, firm's age and industry.

As said previously a 'cross-section' PSM is run to deal with the moving year of entry. PSM should generally reduce the bias of estimators because it compares the treated and untreated firms based on their similar observable characteristics, assuming that unobserved characteristics are comparable as well. However, the sample size now is significantly smaller, likely leading to bigger standard errors, which is important to note when interpreting the results.

In Table 4.9, the results for the logit regression used to identify the variables that drive the receiving of grants are presented. For every observation, the dependent variable is dichotomous, using 1 if the grant was received and 0 if it was not received. As noticed, firm size has significant effect on being treated.

Table 4.9 Propensity-score matching results

Variable	Coefficient b/se
Firm size	0.512**
	0.2
Firm age	-0.0012
	0.029
Industry dummy	Insignificant
Constant	-3.69
	0.6

Source: ABS; Author's calculations

Then using these results, the common support is generated to do the analysis, as presented in Table 4.10. As a 'cross-sectional' PSM is carried out, some firms who received the grants later on are excluded.

Table 4.10 Common support

	Common Support		
Treated	**Out**	**In**	**Total**
No	0	873	873
Yes	1	46	47
Total	1	919	920

Source: ABS; Author's calculations

Table 4.11 presents the results from the near-neighbour matching approach, where the grant impact on different outcome variables is measured, through using the computed propensity score to match each of the grant recipient firms with the most similar non-recipients' innovative firms. The results do not show any significant impact on the different dependent variables.

Table 4.11 Estimated impact using PSM

Variable	ATT	Std err	t
Innovation introduced	0.056	0.080	0.70
Goods and/or services innovation	0.073	0.081	0.91
Operational processes innovation	-0.065	0.800	-0.81
Organisational/managerial processes innovation	-0.043	0.081	-0.53
Marketing methods innovation	0.091	0.080	1.13

Source: ABS; Author's calculations

The process is repeated using a further different approach, like kernel matching with and without the sensitivity analysis, where the 5% of treated firms are trimmed. In general, the results using different techniques have shown no indication of any significant impact on the outcome variables. Most likely this means that the propensity-score matching using different approaches does not completely exploit the longitudinal structure of the data. As described above, the fixed-effects panel regression did show significant results.

4.6.2 Results of firm analysis for business performance indicators

4.6.2.1 Ordinary least squares analysis and estimated results

First, a conventional linear regression model using ordinary least squares model (OLS) is estimated. This method allows examination of the relationship between receiving the grant and all the three variables of interest, while holding constant other observable characteristics of the firms.

These results are presented in Table 4.12. On average across all years, firms that received grants had a 41% sales increase and 38.5% more employment. The results for labour productivity were insignificant.

When using OLS all observations are weighted equally which increases the potential for unobserved characteristics to influence the results (Valera 1978). In order to reduce the potential bias, the coefficients are estimated through comparison between 'similar' firms and using matching techniques.

Table 4.12 Business performance indicators, OLS, full sample

(continued on next page)

Variable	Log of Labor Productivity				Log of Sales				Log of Employment			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Treatment Dummy	**0.045**	**0.037**	**0.038**	**0.038**	**0.426*** **	**0.42*** **	**0.433*** **	**0.411*** **	**0.381*** **	**0.405*** **	**0.403*** **	**0.385*** **
(Grant)												
	0.039	0.04	0.041	0.042	0.057	0.059	0.059	0.06	0.084	0.089	0.089	0.09
Total Sales	4.88E-	4.82E-	4.7E-	4.7E-	8.2E-	8.06E-	7.88E-	7.87E-	2.87E-	2.76E-	2.65E-	2.65E-
	08***	08***	08***	08***	08***	08***	08***	08***	08***	08***	08***	08***
	2.90E-09	2.87E-09	2.93E-09	2.93E-09	5.42E-09	5.35E-09	5.43E-09	5.44E-09	6.19E-09	6.05E-09	6.02E-09	6.01E-09
Ratio Exports/Sales	-0.083	-0.089	-0.1	-0.1	-0.088	-0.091	-0.109	-0.11				
	0.052	0.049**	0.043**	0.043**	0.037**	0.036***	0.03***	0.03***				
Firm Age									0.045***	0.045**	0.044**	0.045**
									0.019	0.019	0.019	0.019
Firm Age Squared									-1.3E-3	-2.14E-4	-2.14E-4	-2.14E-4
									1E-03	0.00087	0.00087	0.00087
Collaboration		0.031	0.017	0.017		0.191**	0.172**	0.159*		0.247*	0.234	0.214
		0.056	0.056	0.056		0.081	0.081	0.081		0.147	0.146	0.148
Foreign Ownership			0.321***	0.32***			0.532***	0.521***			-4.59E-10	-4.37E-10
			0.085	0.085			0.122	0.122			9.73E-	9.86E-
											11***	11***
Location			-2.72E-10	-2.72E-10			-5.33E-10	-5.36E-10			0.317**	0.312**

			1.76E-10	1.76E-10			2.13E-10**	2.13E-10**			0.135	0.135
Tax incentive				0.005				0.242**				0.212
				0.065				0.103				0.171
Industry Controls	N	N	N	Y	N	N	N	Y	N	N	N	Y
Time Dummy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
R2			0.25	0.25			0.29	0.29	0.18		0.19	0.19
Sample Size	9587	9175	9146	9146	10447	9963	9926	9926	1965	1832	1821	1821

Notes: *, ** and *** denote coefficient estimates are statistically significant at the 10%, 5% and 1% levels respectively; standard errors are below the coefficients.

Sources: ABS; Authors' calculation

4.6.2.2 Panel estimates: full sample

Table 4.13 summarises the first set of results. Parsimonious model specification is used. Three outcome measures are selected for study: labour productivity, sales, and employment.[57] These outcomes are related to the program variable and control variables: total sales, ratio exports/sales, cooperation for R&D, foreign ownership, location, tax incentive, industry division, and time.

All four different models have consistent results and show that the average impact of the program (grants) over the whole period is positive for both outcomes of interest.

The grant status also has a positive impact on labour productivity with 6.4% of increase on average for grant recipients and on the total sales, with 7.2% increase on average.

Estimates for the treatment variables are consistent between all four different models, when adding new explanatory variables. Further, controlling for the effects of tax incentive made the estimates for financial grants more robust, as grants are having positive impact on all business performance indicators.

Differences in the estimates between different models and the baseline model show that for both business performance indicators, a small decrease in coefficients can be noticed as more variables are added/ with the progress from the baseline to the expanded model, but all coefficients remain significant. As more variables are added, the explanatory power of the model is increased and is getting closer to the true parameters of the expended model, hence the expanded model is chosen as the final model. From baseline model to expanded model

[57] Fixed effects could not be run for total employment owing to collinearity with independent variables and few variations within firms.

about a 0.7% decrease is seen in the impact treatment has on having on labour productivity and 0.4% decrease in the impact treatment has on total sales.

Table 4.13 Panel regression coefficients for business performance indicators, full sample

Impact Variable	Log of Labour Productivity						
	Model 1 Hall's		Model 2		Model 3		Model 4
Treatment Dummy (Grant)	**0.071****		**0.063***		**0.064****		**0.064***
	0.032		0.033		0.033		0.033
Total Sales	3.07E-08***		0.0000000303***		0.0000000303***		3.03E-08
	4.81E-09		4.82E-09		4.81E-09		4.81E-09
Ratio Exports/Sales	-0.07		-0.087		-0.088		-0.088
	0.023***		0.022***		0.022***		0.022***
Collaboration			0.01		0.011		0.011
			0.042		0.041		0.041
Foreign Ownership					-0.099		-0.1
					0.091		0.092
Location					-1.67E-10		-1.67E-10
					1.11E-10		1.11E-10
Tax incentive							0.011
							0.046
Industry controls	N		N		N		N
Time Dummy	Y		Y		Y		Y
R2	0.04		0.04		0.04		0.04
Sample Size	9587		9175		9146		9146
Impact Variable	**Log of Sales**						
	Model 1 Hall's		Model 2		Model 3		Model 4
Treatment Dummy (Grant)	**0.076****		**0.073****		**0.075****		**0.072****
	0.03		0.031		0.031		0.031
Total Sales	3.86E-08***		3.79E-08***		3.78E-08***		3.78E-08***
	6.00E-09		5.94E-09		5.93E-09		5.93E-09

Ratio Exports/Sales	-0.098		-0.108		-0.108		-0.107
	0.025***		0.02***		0.02***		0.019***
Collaboration			0.021		0.021		0.02
			0.04		0.04		0.04
Foreign Ownership					-0.066		-0.068
					0.09		0.091
Location					-2.04E-10		-2.06E-10
					9.15E-11***		9.13E-11***
Tax Incentive							0.06
							0.037
Industry Controls	N		N		N		N
Time Dummy	Y		Y		Y		Y
R2	0.06		0.07		0.07		0.07
Sample Size	10447		9963		9926		9926

Notes: *, ** and *** denote coefficient estimates are statistically significant at the 10%, 5% and 1% levels respectively; standard errors are below the coefficients. Marginal effects are reported. Diff is the difference in the estimates between different models.

Sources: ABS; Authors' calculation

4.6.2.3 Panel estimates: innovative firms only sample

Table 4.14 summarises the second set of results for the subsample of only innovative firms. Again, a parsimonious model specification is used. Three outcome measures are selected for study: labour productivity, sales and employment.[58] These outcomes are related to the program variable and control variables: sales, ratio export/sales, cooperation for R&D, foreign ownership, location, tax incentive, industry division, and time.

Estimates for the longer-term business performance, as labour productivity and total sales, show positive significant impact only for Model 1, with 6.5% and 5.8% respectively. There is no significant impact for the rest of the models.

[58] See footnote 13 above.

Table 4.14 Panel regression coefficients for business performance indicators, innovative sample

Impact Variable	Log of Labour Productivity				Log of Sales			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Treatment Dummy (Grant)	**0.065****	0.054	0.0534	0.053	**0.058***	0.051	0.051	0.049
	0.037	0.038	0.038	0.038	0.033	0.035	0.035	0.034
Total Sales	2.97E-8***	2.94E-8***	2.94E-8***	2.94E-8***	3.41E-8***	3.34E-8***	3.34E-8***	3.33E-8***
	3.78E-09	3.77E-09	3.77E-09	3.77E-09	5.07E-09	4.95E-09	4.94E-09	4.94E-09
Ratio Exports/Sales	-0.021	-0.024	-0.024	-0.024	-0.033	-0.036	-0.037	-0.037
	0.026	0.027	0.027	0.027	0.029	0.031	0.031	0.031
Collaboration		-0.007	-0.007	-0.07		0.011	0.011	0.01
		0.044	0.044	0.044		0.045	0.045	0.045
Foreign Ownership			-0.117	-0.118			-0.034	-0.035
			0.099	0.099			0.117	0.117
Location			-2.56E-10	-2.56E-10			-2.49E-10	-2.50E-10
			1.55E-10	1.55E-10			1.40E-10	1.40E-10
Tax Incentive				0.02				0.036
				0.048				0.042
Industry Controls	N	N	N	N	N	N	N	N
Time Dummy	Y	Y	Y	Y	Y	Y	Y	Y
R2	0.05	0.05	0.05	0.05	0.07	0.07	0.07	0.07
Sample Size	6754	6470	6456	6456	7148	6823	6805	6805

Notes: *, ** and *** denote coefficient estimates are statistically significant at the 10%, 5% and 1% levels respectively; standard errors are below the coefficients. Marginal effects are reported.

Sources: ABS; Authors' calculation

4.6.2.4 Propensity-score matching analysis and estimated results

The third set of results, using PSM, are depicted in Tables 4.15, 4.16 and 4.17 respectively. The sample is restricted to compare treated with untreated firms which are similar in their pre-treatment observable characteristics.

As said previously a 'cross-section' PSM is run, to deal with the moving year of entry. PSM shall generally reduce the bias of estimators because it compares the treated and untreated firms based on their similar observable characteristics, assuming that unobserved characteristics are comparable as well. However, the sample size now is significantly smaller, likely leading to bigger standard errors, which is important to note when interpreting the results.

In Table 4.16, the results for the logit regression used to identify the variables that drive the receiving of the grants are presented. For every observation, the dependent variable is dichotomous, using 1 if the grant was received and 0 if it was not received. As noticed, firms size has significant effect on being treated.

Table 4.15 Propensity-score matching results

Varable	Coefficient b/se
Firm size	0.512**
	0.2
Firm age	-0.0012
	0.029
Industry dummy	Insignificant
Constant	-3.69
	0.6

Source: ABS; Author's calculations

Then using these results, the common support is generated to do the analysis, as presented in Table 4.16. As a ‘cross-sectional’ PSM is carried out, some firms who received the grants later on are excluded.

Table 4.16 Common support

	Common support		
Treated	**Out**	**In**	**Total**
No	0	873	873
Yes	1	46	47
Total	1	919	920

Source: ABS; Author’s calculations

Table 4.17 presents the results from the near-neighbour matching approach, where the grant impact on different outcome variables is measured, through using the computed propensity score to match each of the grant recipient firms with the most similar non-recipients’ innovative firms. The results do not show any significant impact on the different dependent variables.

Table 4.17 Estimated impact using PSM

Variable	ATT	Std err	t
Sales	-0.11	0.255	-0.45
Employment	0.022	0.163	0.14
Wages	-0.077	0.28	-0.27
Labour productivity	-0.136	0.196	-0.7

Source: ABS; Author’s calculations

The process is repeated using a further different approach, like kernel matching with and without the sensitivity analysis, where the 5% of treated firms are trimmed. In general, the results using different techniques have shown no indication of any significant impact on the outcome variables. Most likely this means that the propensity-score matching using different approaches does not completely exploit the longitudinal structure of the data. As described above, the fixed effects panel regression did show significant results.

4.6.3 Summary of results and comparison with existing evidence

A detailed summary of the full statistical results is given in the Tables 4.6 to 4.17 above. A summary of their standing is given here now in Tables 4.18 to 4.21 so that the Australian estimation can be directly contrasted with the earlier work and the Augmented Model (Model 4) compared to the Baseline Model (Model 1).

For Model 1, both the conventional linear regression model using OLS and fixed effects model are estimated. The detailed results are presented in the appropriate previous subsections. What is noticeable, and is reported comprehensively, is that the estimation results with respect to coefficients are similar between all models.

For innovative outputs, Hall used only goods and/or services and operational processes innovation, while this analysis is using these plus three more: if any type of innovation was introduced, if there was organisational/managerial processes innovation or if there was marketing methods innovation. All of the estimates for the treatment variable (receiving the grant) have significant and positive effect on the innovative outputs. Note that this analysis reported odds ratio rather than marginal effects (see Table 4.18).[59] Here, therefore, Hall for Australia is re-estimated and a wider range of innovation and obtain significant results using the Hall model.

Table 4.18 Innovative output, comparison table for these estimates and Hall's (2008)

Indicator	**Impact Australia**	***Significance***	**Impact Hall *et al*. (2008)**	***Significance***
Innovation introduced	1.72	1%	N/A	
Goods and/or services innovation	1.56	1%	-1.45 to 0.08	NS or 5 %
Operational processes innovation	1.69	1%	0.1 to 0.46	5–10 %
Organisational/managerial processes innovation	1.67	1%	N/A	
Marketing methods innovation	1.45	5%	N/A	

Source: Hall *et al.* (2008); ABS; Author's calculations

All results are significant at the 1% level, except marketing innovation, which is significant at the 5% level. This means that the estimates for the treatment variable are less than 1% likely to be due to chance. According to these estimations, for the grant recipients about 72% increase in the odds of having an innovation output (any type of innovation) is expected; 56% increase in the odds of having a goods and/or services and/or process innovation is expected; 69% increase in the odds of having operational processes innovation is expected; 67%

[59] For more information, see Subsection 6.1.

increase in the odds of having organisational/managerial processes innovation is expected and 45% increase in the odds of having marketing methods innovation is expected.

Table 4.19 presents the effects on the treatment variable (receiving grant) on the innovative outputs, from the Baseline Model (model 1) and the Final Augmented Model (Model 4). All estimates are very similar, significant and positive.

Table 4.19 Innovative output, comparison table for estimates with the Baseline Model (Model 1) and the Augmented Model (Model 4)

Indicator	**Impact from Table 4.7 (Model 1)**	***Significance***	**Impact from Table 4.7 (Model 4)**	***Significance***
Innovation introduced	1.72	1%	1.65	1%
Goods and/or services innovation	1.56	1%	1.48	1%
Operational processes innovation	1.69	1%	1.61	1%
Organisational/managerial processes innovation	1.67	1%	1.56	1%
Marketing innovation	**1.45**	**5%**	**1.35**	**10%**

Source: ABS; Author's calculations

Table 4.19 (Model 1) presents the full range of innovation measures from the Hall *et al*. (2008) model, while Model 4 in Table 4.19 presents Final Augmented Model and the results are strong and similar.

Moving beyond the range of innovation indicators, to the business performance indicators, the estimates for the treatment variable (receiving the grant) have a significant and positive effect on labour productivity (7.1%), sales (7.6%), and total employment (38%)[60] (see Table 4.20). Results are in the range of those from Hall *et al*. (2008).

Table 4.20 Business performance indicators, comparison table of these estimates and Hall's (2008)

Indicator	Impact Australia (Model 1)	*Significance*	Impact Hall *et al*. (2008)	*Significance*
Labor productivity	7.1 %	5%	-85.4% to 27.5%	NS
			14%	5%
Sales	7.6%	5%	2.57 to 39.6%	NS
			64%	5%
Employment	**38% (OLS)**	**1%**	**1.5%to 12%**	**NS**
			79%	**1%**

Source: Hall *et al.* (2008); ABS; Author's calculations

Further, the estimation coefficients are again almost identical between the Baseline Model and the Final Augmented Model. The grant status has a positive significant impact on labour productivity with a 7.1% increase on average for grant recipients (compared to 6.4% from the Final Augmented Model) and a 7.6% increase on average on total sales, with (compared to a 7.2% increase in the Model 4, see Table 4.21).

[60] See note 13 above.

Table 4.21 Business performance indicators, comparison table for estimates of the Baseline Model and the Augmented Model

Indicator	Impact from Table 4.13 (Model 1)	*Significance*	Impact from Table 4.13 (Model 4)	*Significance*
Labor productivity	7.1%	5%	6.4%	10%
Sales	7.6%	5%	7.2%	5%
Employment	**38.1 % (OLS)**	**1%**	**38.5 % (OLS)**	**1%**

Source: ABS; Author's calculations

As a robustness check, the Hall's model is used on the innovative sample of firms as well, and the results are consistent with the results from the full sample and across different models. All estimates for innovative outputs are positive and significant.

According to these estimations (see Model 1 in Subsection 6.1), for the grant recipients about 65.6% increase in the odds of having an innovation output (any type of innovation) at 1% level of significance is expected; 56% increase in the odds of having a goods and/or services or service innovation at 5% level of significance is expected; 48% increase in the odds of having operational processes innovation at 5% level of significance is expected; 68.7% increase in the odds of having organisational/managerial processes innovation at 1% level of significance is expected and 32.3% increase in the odds of having marketing methods innovation at 10% level of significance is expected.

Estimates for the longer term business performance (see Model 1 in Subsection 6.2) showed a 6.5% increase on average in labour productivity for grant recipients at 5% level of significance and 5.8% increase on average at 10% level of significance on total sales. The result for the total employment is positive and significant from the ordinary least square model only.

4.7 Conclusions

This essay explores the impact of the grants system provided by the Australian government for innovative entrepreneurs in Australia from 2006 to 2011. This study is thought to be the first thorough, firm-level impact evaluation of the effects of public grants on innovative firms in Australia. Further, this is the first impact evaluation for Australian firms across all sectors that focuses not only on innovative outputs, but also on business performance. As the innovations increase the social returns, hence affecting social welfare, looking only at the input side of innovation efforts is not enough to properly evaluate its impact.

It is therefore important that the analysis of the essay does conclude that the grant scheme has been successful in increasing firms' propensity to innovate. Irrespective of which model specification and estimation methods are adopted, the estimates illustrate significant positive impact of the grants on innovation outputs and business performance[61]. Further, to some extent, the grants scheme mostly seems also to enhance overall longer-term business performance in labour productivity, sales and employment, but with less effect than for innovation output. The findings demonstrate that the impact of the grants on firms is strongest for the immediate target of the public financial instrument, the innovative outputs, while it becomes weaker as the firms move from output additionality to performance indicators. However, this is expected as business performance needs a longer window for those impacts to have an effect. Indeed, it is very possible that the five-year timeframe of the

[61] The author wants to point out again that there was no control for unobservable time varying factors.

dataset is not enough for those impacts to fully occur. The results have highlighted the need for following firms over longer periods.

The reported results also complement previous findings that public support for innovation positively affects output additionality. The results fall within the range for estimates for the direct public financial support for innovative businesses by the international literature and is close to benchmark estimates of authors such as Hall *et al*. (2008).

On the other hand, these findings should be treated cautiously as there are some important qualifications. While the fixed effects models are able to control for potential correlation between unobserved heterogeneity and time-varying explanatory variables, the endogeneity issue is a task for future research. Estimating the average treatment effect turned out to be a demanding task, but one that can be enhanced over time.

First, enhancement is feasible because this analysis presents relatively medium-term impact only. The grants scheme has existed for decades and it is still expanding. But the available datasets are five years only, with unavailability for merging different panels and following the firms recipients through the years. Some firms had been receiving grants for many years during and before the sample period, and some for first time. Hence there is a mix of average long-term and short-term effects presented in the results.

Second, dataset characteristics and many important variables are missing from the ABS data set, which has limited here the possibility of using different approaches and hence depth of analysis.

Below are presented a number of ways this analysis can be taken forward in the future, as revealed by the analysis in the present study.

- Knowing better the criteria the government decides on for grant procedures will improve the matching approaches by knowing which observables to focus on, hence improving the overall effectiveness and analysis.
- If there are policy shifts in the future, they should be clearly defined, allowing for researchers to use other quasi-experimental approaches such as difference in difference and regression discontinuity design, increasing the internal validity of the results.
- For estimating the impact on business performance, as the end goal of the innovative policies for businesses, longer coverage and following the firms through the years, merging of different sample should be allowed, and the datasets should be enriched with more important information.
- Unfortunately, the feature of this scheme doesn't allow for randomisation, which would have been the most powerful approach to evaluate the impact. However, having data on which firms received the grants and which are rejected and their information from before and after, will allow for stronger approaches or a mix of them, to have results valuable for domestic and international use.
- Descriptive statistics point to an important factor for further analysis and for policy: innovative firms and firm that receive grants are usually older and bigger firms, unlike the intention of those grants to give access to finance for smaller and younger firms who need them. This should be further investigated, as the biggest access to finance barriers are experienced by younger and smaller firms.

A final observation is to attest the value of taking a benchmark global analysis and applying it to new data, such as for Australia, and validating that analysis through the latest methods of estimation. This means that policy advances can be based on a more secure analytic foundation, both for Australia and, through the marketplace of ideas, for other countries too.

4.8 Appendix

Table 4.22 Summary of relevant research

Author(s)	**Country**	**Data source**	**Method**	**Outcome variable(s)**	**Sample size**	**Method**
Aerts and Czarnitzki (2004)	Belgium	CIS3 (1998–2000)	Non- parametric matching	*Input additionality* R&D expenditure R&D intensity *Output additionality* Number of firms with patents Number of patents per employee	776 firms, 180 treated	Firm size Patent stock Exports Capital intensity Cash flow per employee Debt per employee Foreign parent
Alecke *et al.* (2012)	East Germany	GEFRA Business Survey in 2003	Non-parametric matching	*Input additionality* R&D intensity *Output additionality* Number of patent applications	1,267 firms, 284 treated	Firm size Firm age Capital intensity Investment intensity

						Percentage of highly skilled workers in total number of employees Export ratio Industry dummy Firm's legal form Belonging to a group Dummy for having R&D department
Aschhoff (2009)	Germany	Pooled CIS dataset (1994–2005)	Non-parametric matching	*Input additionality* R&D expenditure *Output additionality* Sales of new products	3,583 firms	R&D expenditure (in total, for firms without grants; with grants, for first time; being recipients more times) Log of sales of new Log of sales of new squared Log of patents Industry dummy Time dummy
Crespi *et al*. (2011)	Colombia	IIAP (1995–2007)	Fixed Effects	*Output additionality* Product Innovation Labour productivity		

Czarnitzki *et al*. (2011)	Canada	IS 1999	Non-parametric matching	*Output additionality* Number of new products Sales of new products Profitability Domestic market share International market share Keeping up with competition		
Garcia and Mohnen (2010)	Austria	CIS3 (1998–2000)	System of simultaneous equations	*Input additionality* R&D expenditure *Output additionality* Sales of new-to-firm products Sales of new-to-market products	546 firms	Firm size Competition Cooperation Human capital Appropriability Access to finances difficulties Demand pull Belonging to a group Foreign parent Science push

						Industry dummy
Foreman-Peck (2013)	UK	CIS4, (2002–2004)	Non-parametric matching	*Output additionality* Either product or process innovation (either new to the firm or to the market)	12,199 firms	Turnover Firm size Regional and industry dummy Exports Belonging to a group Number of employees with higher degree Percentage of highly educated employees in the total Collaboration R&D over turnover Plant and machinery investment over turnover
Hall and Maffioli (2008)	Argentina, Brazil, Chile, Panama	Innovation panels	Non-parametric matching DID Fixed effects	All additionalities	Different models with different data	Many different variables
Herrera *et al*. (2010)	Spain	Business Strategy Survey (1999–2000)	Non-parametric matching	*Input additionality* R&D intensity	1,718 firms, 208 treated	Firm size Firm age

				Output additionality Number of patents per employee		Previous R&D expenditure Firm's ownership Access to finance Growing market Market concentration Export propensity Regional and industry dummy
Herrera and Sánchez González (2012)	Spain	PITEC (Panel of Technological Innovation) dataset (2003–2007)	Non-parametric matching	*Input additionality* Private R&D intensity *Output additionality* Sales of new products	4,713 firms, 1,218 treated	Log of firm size Firm age Dummy for foreign capital percentage of exports in sales Continuous R&D activities Sales of new-to-market products publicly funded Industry dummy
Hewitt, Dundas and Roper (2010)	Ireland and Northern Ireland	Pooled Irish Innovation Panel (IIP) (1994–2002)	Instrumental variables	*Output additionality* Sales of new products Sales of new and improved products	1,571 observations	In-house R&D Supply chain links Non supply chain links Plant size squared

				Product innovation		Type of production Part of multi-plant group Externally owned plants Workforce qualifications Capital investment per employee Industry dummy
Hujer and Radic (2005)	Germany	IAB Panel (1997–2001)	Non-parametric matching Simultaneous equations Difference- in-differences	*Output additionality* Product innovation	2,714 firms, 492 treated	Firm size Percentage of only owner firms Percentage of partnerships Percentage of private limited firms Percentage of capital firms Competition intensity Gini concentration Export R&D collaborations State of technology

						Existence of separate R&D department Percentage of highly-skilled employees
Hussinger (2008)	Germany	CIS with BMBF Pooled cross dataset (1992–2000)	Heckman selection model and semi-parametric selection models	*Input additionality* R&D expenditure divided by the number of employees *Output additionality* Sales of new products	3,744 observations, 723 treated firms	Firm size Firm age Market concentration Patents per employee Credit rating index Export intensity International parent firm
Marino *et al* (2010)	Denmark	IDA (1997–2005)	Non-parametric matching	*Input additionality* R&D expenditures *Output additionality* Number of patent applications *Behavioural additionality* Percentage of R&D employees	268 firms	Total assets value Firm size Indebtedness R&D intensity Public funding intensity Percentage of highly-skilled employees Exports Industry dummy Time dummy

Marzucchi (2011)	Italy and Spain	CIS4 (2002–2004)	Non-parametric matching	*Input additionality* R&D expenditure R&D intensity *Output additionality* Process innovation Sales due to new products Sales of new-to-firm products Sales of new-to-market products patent application *Behavioural additionality* Formal training program Collaboration with other firms Collaboration with research entities	7,905 firms in Spain and 3,851 in Italy	Log of turnover Firm size Affiliation with internationals Exports R&D activities Permanent R&D activities Lack of internal funds Lack of access to external funds Government sources of information Industry dummy

Lopez-Acevedo and Tan (2010)	Chile	Innovation and Enterprenurial Panel (1992–2006)	Non-parametric matching with difference-in-differences	*Output additionality* Product or process innovation Labour productivity		
Reinkowski *et al*. (2010)	Germany	Business Survey 2004 (2001–2003)	Non-parametric matching	*Input additionality* Log of R&D intensity *Output additionality* Number of patents	1,484 firms, 284 treated	Log of firm size Log of firm age Log of firm age square Percentage of high-skilled employees Sales in regions Dummy for having an R&D department
Schneider and Veugelers (2010)	Germany	CIS4 (2002–2004)	Instrumental variables Percentage of subsidised firms in the region Percentage of subsidised firms in the sector	*Output additionality* Sales of new products Sales of new-to-firm products Sales of new-to-market products	1,715 firms	Log of employment Log of firm's age R&D intensity External sources of knowledge Belonging to a group Industry dummy

Chapter 5 Conclusion

Innovation policy has acquired a central role among policy makers, with economic theory and empirical studies pointing to such innovation as one of the key drivers of economic growth, making firms more competitive through increasing their productivity and the quality of good and services (Schumpeter 1939; Bartel *et al.* 2007; Griffith *et al.* 2006; Hall *et al.* 2009; Halpern *et al.* 2012; Palangkaraya *et al.* 2015; Raymond *et al.* 2010). 'Innovation is widely considered as the life blood of corporate survival and growth' (Zahra *et al.* 1994). Due to many market failures and other constraints on innovators, as discussed in detail in Essay 1 (Chapter 2), governments have considered many different ways to support innovative activity, especially through the lens of whole national innovation systems.

Findings from the case for Australian firms reveal that only 20–25% of innovative entrepreneurs seek external funding (ABS 2011). Smaller and younger firms are more innovative, according to some authors, who have found that the older and the larger the firm, the less innovative activities it exhibits (Abdelmoula *et al.* 2010; Acs *et al.* 1987; Becheikh *et al.* 2006). Innovative entrepreneurs have been recognised as crucial for sustainable economic growth, responsible for moving the economy from static equilibrium. If Australia wants to shift towards ‘new-to-market’ innovation, and be a leader in innovation, focus must be given more to young and high-growth firms rather than bigger, older firms. Instead of significant innovation, bigger firms tend to improve their current competencies, while young, small and high-growth firms are more inclined towards radical, new-to-market innovations (Baumol 2002; Henderson 1993; Vaona and Pianta 2008).

That said, there can be argument over whether a consequent policy focus is best placed on new and innovative firms or older and bigger firms, since there can also be a view that the latter are further behind the best practice frontier and hence there may be more value-add per policy dollar ie do you direct programs toward the leaders or the laggards or both? This is a matter though of detailed policy design for the policy makers and so is not further pursued here, as is indicated above for such issues.

In this final chapter, the summary of results and findings from the three essays is presented, followed by lessons for public policy and suggestions for possible further research. The thesis contributes new theoretical approaches and empirical evidence on financing business innovations by addressing three separate but related questions.

1. Is RCL a potentially effective instrument in addition to the existing traditional private financing approaches?
2. With respect to likely government subsidies, can RCL be useful as an addition, or as an alternative, to public assistance for business innovation depending on different parameters in its design?
3. Has public assistance for innovation through innovation grants been effective with respect to increasing innovative activities and business performance in Australia?

In addressing these questions, the thesis offers three significant contributions to the economics of innovation literature. First, the theoretical discussion positions RCL alongside other forms of financing for the firm. Second, it demonstrates the trade-offs in RCL policy design in terms of government subsidies with respect to interest rates, collection rates, grace periods, the size of debts and more. Third, the empirical analysis illustrates that government grants for business innovation in Australia have positive effects on both innovation incidence and extent, but there are important caveats concerning the findings, notably with respect to selection and endogeneity.

In the first essay, the conceptual role of RCL is examined with respect to finance for SME innovations. It is first argued that deficiencies in access to finance are a burden with respect to existing business innovation support arrangements, resulting in sub-optimal financing of innovations due to many market failures. In light of clear returns to society from innovations, beyond private returns for the firms, reasons why government should step in to assist in financing business innovations are provided. Arguments for considering appropriately designed RCL for financing business innovations are then provided. Finally, and most importantly, another contribution of this first essay is the theoretical comparison of RCL, debt and equity financing on a firm's cash flow and on innovators' efforts, using the capital structure theory of Modigliani and Miller (1958), contract theory (Laffont and Martimort 2002; Bolton and Dewatripont 2005) and neoclassical microeconomic theory for profit functions and maximising values for quantity, price and profit. The findings suggest that innovator's efforts are affected only by RCL and not by debt and equity financing.

The second essay provided the first study to examine the implications of potential RCL design with respect to government subsidies for innovation activities. In this essay key design features for the RCL are presented. First, a grace period of three years is given to all firms as borrowers to reduce the financial burden at start. Second, there is no minimum repayment threshold, rather firms are obliged to pay a certain rate of their annual revenues. Third, the models considered various RCL parameters, loan amounts, interest rate, repayment rate, loan surcharge, probability of death of the firms and grace periods to reflect different case scenarios. In the end, taxpayers' subsidies were calculated for all scenarios. The results of the cases highlight key features of the scheme. Firm debtors with smaller firm size tend to repay less compared to the larger firms, or do not repay the loan at all. In this context, this essay presents findings for Australian policy makers to make further decisions on instrument design for a new way forward for such policy.

The first two essays in the thesis dealt with the RCL as a novel public financial product for financing business innovations for the Australian government, which can replace or be additional to the existing public financial instruments. Hence it was logical that the last essay examined if the present public financial products by Australian government were themselves successful in their goal to increase the innovation output and improve business performance in Australia. This study examined the relationship between receiving government financial support and innovation output and business performance, using an ordinary least square regression model (OLS), fixed effects model and propensity-score matching. The results show a positive relationship between grants and the above-mentioned output variables, but limitations of both the data and of method suggest significant caution in the interpretation of these relationships as causal.

This empirical research in the thesis improves the current econometric modelling of the relationship between receiving public grants for innovation and innovative activity and business performance, in terms of model specification. It controls for important covariates that the previous studies did not consider, such as collaboration for R&D and receiving other financial instruments. Previous studies consistently focused on R&D expenditures rather on innovative activities, primarily due to lack of data and panel datasets. The original contribution of this study is that it is the first to address the issue of the treatment effect of public financial grants on total innovative activities of firms across all sectors in Australia, and not only on innovative outputs but on their economic performance as well.

Overall, this thesis adds to the understanding of the scope, design, and effectiveness of public direct financing instruments for financing business innovations. This research might also be informative to other countries with well-established tax collection systems for judging the benefits of adding an alternative public scheme (i.e. RCLs) for financing business innovations.

The findings reported in this thesis should be of interest for policy makers. Governments have realised the importance of innovation for economic growth and accordingly have shaped policies for stimulating innovation. This essay has suggested a different public financial instrument that can be used instead of present grants for financing business innovations in Australia. While grants have been shown in this thesis to be beneficial for innovation and more work on the precise form of a revenue-contingent loan is needed, the basic fact is that a loan has direct repayments and grants do not. Administration costs of RCLs are also likely to be relatively manageable. Hence the potential cost-effectiveness of RCLs relative to grants is very clear, and promotesthe case for their close consideration for policy.

This instrument was first suggested by Dadd and Withers (2004). Later, Higgins and Withers (2009) surveyed public opinions regarding potential uses of income contingent loans (ICL) in other areas beyond tertiary education in Australia and one such use was ICL for innovations and R&D. Their results have shown that over 60% of the respondents agreed with the idea of contingent loans for innovations and R&D, while only a small percentage (less than 5%), were against the idea.

The particular merits are:

- RCL would be helpful for financially constrained SMEs, which do not have many financial options, especially in the initial financing phase, as RCLs would not require a collateral nor a potential loss of ownership
- RCL would release the financial pressures and risk of bankruptcy for firms, providing a revenue smoothing
- RCL would be a more sustainable way for governments to budget as, compared to the 'giving away' of tax-payers money through grants, the money allocated through RCL would provide a return into the pool for future financing
- There is no complete private market for RCLs, and due to the 'transactional efficiencies' and being a precedent claimant, governments can fill in the gap in loan markets, through risk pooling.
- Applying a cohort premium risk interest rate on RCLs would reduce the pressure on all taxpayers, as the successful innovators, and not taxpayers,would subsidise for the unsuccessful applicants.

As suggested by Denniss *et al.* (2009), this instrument could be implemented through an Innovation Development Fund where, alongside the loans themselves, training and improvement of various skills (administration, business, etc.) could also be provided. The financing approach could be a part of a hybrid public financial instrument, in combination with both debt and equity financing, according to a firm's needs.

Finally, ongoing research in this field is recommended and some priorities for this have been identified in this study.

First, the theoretical comparison could be further improved by incorporating asymmetrical information as the future extension of the model, thus comparing debt, equity and RCL financing even more comprehensively.

Second, the exercise carried out in the second essay relies on static revenue profiles that do not change over time, which is not realistic and is rather deterministic by nature. A further exploration using dynamic modelling will be useful. This further knowledge would also be valuable to the policy makers in order to implement RCLs successfully.

The third area for further research pointed to here is estimating costs and benefits of the RCL to evaluate its viability in the long term. In taking this further for specific RCL policy initiatives where other policy already exists, such as grants, their introduction may affect firms' behaviour, which must be allowed for; to assist here, hybrid polices might be considered at least as intermediate alternatives.

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